Novices' Learning from the Internet: An Exploration of Navigation Behaviours, Learner-related Factors, and Mental Effort

By

Malinda Desjarlais

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Department of Psychology
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Abstract

The current study was an exploration of why some novices are more successful than their peers when learning from the Internet by examining the relations among time spent with relevant information and changes in invested mental effort during Internet navigations as well as achievement. Navigation behaviours and learner characteristics were investigated as predictors of time spent with relevant information and changes in mental effort. Undergraduates ($N = 85$, $M_{age} = 20$ years, 5 months) searched the Internet for information corresponding to a low knowledge topic for 20 min while their eye gaze and pupil size were recorded. Pupil diameter was used as an objective, continuous measure of mental effort. Participants also completed questionnaires or computer tasks pertaining to self-regulated learning characteristics (general intrinsic goal orientation and effort regulation) and cognitive factors (working memory control, distractibility and cognitive style). All analyses controlled for general mental ability, reading comprehension, topic and Internet knowledge, and overall motivation. A greater proportion of time spent with relevant information predicted higher scores on an achievement test. Interestingly, time spent with relevant information partially mediated the positive relation between the frequency of increases in invested mental effort and achievement. Surprisingly, intrinsic goal orientation was negatively related to time spent with relevant information and effort regulation was negatively related to the frequency of increases in invested mental effort. These findings have implications for supports when novices guide their own learning, especially when using the Internet.

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The Internet, a type of hypermedia, is a widely used resource for finding and retrieving information, particularly for high school and university students (Dryburgh, 2001; Jones, 2002). In a survey of 25,090 Canadians, 90% of adolescents between the ages of 15 and 19 years reported accessing the Internet during the year 2000 (Dryburgh, 2001). In addition, of the 86% of American post-secondary students who went online in 2002, almost half reported using the Internet prior to arriving at college (Jones, 2002). Over a third of college students indicated accessing the Internet to engage in work for their classes (Jones, 2002). Prevalence of Internet use, however, does not necessarily mean that this is an effective learning tool for all learners. One significant constraint may be when learners have low domain knowledge (typically operationalized as scoring low on a self-assessment of knowledge or below the median score on a pre-test pertaining to a particular domain; Harp & Mayer, 1998; Kopcha & Sullivan, 2008). Learners with low domain knowledge are faced with challenges when trying to comprehend information regardless of the resource. Overall, novices typically have poorly organized domain-related schemas, use ineffective search strategies, and expend a great deal of mental effort when learning new information. Indeed, some researchers have found that learners, on average, have difficulty benefiting from navigating the Internet when domain knowledge is low in comparison to a control group (Willoughby, Anderson, Wood, Mueller & Ross, 2009) or when examining changes in pre- and post-navigation test scores (Lawless, Brown, Mills, & Mayall, 2003). However, in these studies, great variability in performance was also reported, which has implications for the types of supports that might be provided when novices use the Internet. It is important then to determine why some novices are more successful in Internet learning situations than their peers.

For example, navigating the Internet requires learners to guide their own learning. Learners must retrieve target information from a vast collection of resources, and must be able to identify not only quality resources, but also to select relevant information within a particular resource. This step of the learning process may pose difficulties for some novices. Individual differences in learning from the Internet then may be accounted for by the time learners spend with relevant information. In addition, although information processing within a low knowledge domain may impose high cognitive demands, learners may still benefit from using the Internet if they increase mental effort (or try harder) to match such demands. The purpose of the current study was to examine the relation among the amount of time spent with relevant information, changes in learners' invested mental effort, and achievement when novices learn from the Internet. To further understand the basis of individual differences in time spent with relevant information and changes in mental effort when learning from the Internet, I also explored various navigation behaviours, learner-related characteristics, and cognitive factors.

The following literature review is divided into three main sections. First, I discuss information processing when domain knowledge is low. The second section provides potential explanations for why some novices may be more successful when learning from the Internet in comparison to their peers, focusing on time spent with relevant information and mental effort. Finally, I discuss the factors that may predict variability in time spent with relevant information and mental effort, including navigation behaviours, self-regulated learning characteristics and cognitive factors.

Information Processing when Domain Knowledge is Low

When domain knowledge is low, the structure and organization of domain-related networks of information (i.e., schema) may not be conducive to efficient processing. These schemas are typically insufficiently developed such that they lack complexity and validity among their connections (Bjorklund & Schneider, 1996; Chi, 1978; Pressley & Schneider, 1997). Therefore, schemas either lack in the quantity of nodes or contain weak connections that may not reach the threshold for activation during recall. As a result, when novices encounter novel domain-related information, they may experience difficulty creating meaningful associations among the to-be-learned content and when connecting the material to their existing knowledge base (Chase & Simon, 1973; Stein, Morris, & Bransford, 1978). Therefore, the process of creating new connections is challenging, inefficient and effortful for novices (Fincher-Kiefer et al., 1988; Willoughby et al., 2009). It is not surprising then that low domain knowledge has been associated with poor performance in the selection, active processing and the recall of information.

Novices also typically have ineffective search strategies to find and extract information from text (Symons, MacLatchy-Gaudet, Stone, & Reynolds, 2001; Symons & Pressley, 1993) or closed archival information systems, such as PsycINFO (Downing, Moore, & Brown, 2005). This makes it very challenging to identify what information is necessary to be successful, seek out such information in a nonlinear presentation and recognize when additional instruction is needed (Fry, 1972; Lawless & Brown, 1997; Shyu & Brown, 1995). For example, novices have difficulty finding a correct answer even when scanning pages of information that contain the relevant information (Symons & Pressley, 1993).

Furthermore, when domain knowledge is low, learners tend to expel a great deal of mental effort to create a coherent mental model. Once information enters working memory, individuals must actively process the material for both comprehension and retention or it will be lost (Baddeley & Hitch, 1974). This process involves mentally organizing the incoming information into a coherent mental representation, including its key components and how they are related to one another and to existing domain knowledge (Mayer, 2005). Planning and monitoring decisions are necessary as well as the execution of strategies intended to facilitate retention (Mayer, 2005). That is, learners typically choose strategies (e.g., searching, assembling, rehearsing and elaborating) and monitor their performance progress in ways they believe will help to accomplish their learning goals (Winne & Hadwin, 1998; Zimmerman, 1998). The elaborate processing involved in meaningful learning typically requires substantial cognitive processing.

Variability in Achievement among Novices When Using the Internet

Although learners are at a disadvantage when domain knowledge is low, the Internet (a type of hypermedia consisting of text, illustrations, video and/or audio files) is typically viewed as offering advantages to the learner compared to traditional learning contexts. Some researchers suggest that the Internet's nonlinear structure more closely matches individuals' learning processes in comparison to traditional text, promotes active learning, and facilitates learning through the use of multimedia (e.g., Hannafin, Hall, Land & Hill, 1994; Jacobson & Spiro, 1995; Liu & Reed, 1994). Moreover, learners are able to access a vast amount of information on a wide variety of topics at any time and from almost anywhere (Eveland & Dunwoody, 2000). Conversely, others suggest that its unique features such as its nonlinear and non-hierarchical structure, dynamic nature, and lack of quality control may make learning from the Internet very difficult (DeStefano & LeFevre, 2007; Dias & Sousa, 1997; Lidstone & Lucas, 1998). In fact, there has been some evidence to support the latter claim.

Unlike traditional sources of information such as textbooks, information on the Internet may not be arranged in a linear format with an introduction, body, and conclusion, nor does it always come with a readily available table of contents, index, or summary - all of which would logically guide the reader through the information. Similarly, the Internet does not necessarily organize or layer information in the way that traditional sources organize information, for example, from most critical to least critical points, or from general to specific points (i.e., it is non-hierarchical; Willoughby et al., 2009). This lack of structure has been found to be very challenging for learners when domain knowledge is low. Specifically, novices' recall of information is negatively impacted when hypermedia lacks an overview (McDonald & Stevenson, 1998) or the information is not organized and structured in a way that is consistent with students' learning goals (Shapiro, 1999).

In addition to a lack of organization, information is presented on the Internet in such a way that learners are encouraged to take control over their own learning by deciding what content to read, the order in which they wish to read it, and the pace of their learning (Curry, Haderlie, Ku, Lawless, Lemon & Wood, 1999; Eveland & Dunwoody, 2002; Large, 1996). In a learner-controlled setting, such as the Internet, hyperlinks enable students to jump from section to section in any order, likely skipping sections of information entirely. Learners are left to their own resources to determine the relation among the material they access and to decide what information is necessary for successful learning. Moreover, learner control has been suggested to require high investment of mental effort (Conklin, 1987). However, learners with low domain knowledge in particular likely do not know what information they need to retrieve or where to find it, and thus may not be able to efficiently guide their own learning. To investigate this hypothesis, Gay (1986) had undergraduate students with little conceptual understanding for an experimentally-assigned topic study information from a multimedia presentation that either presented information in a pre-specified order or provided learners with control over what information to view and its sequence. Learners performed poorer on retention and recall tests after studying from the learner-controlled multimedia presentation in comparison to the alternate format, supporting the hypothesis that self-sequencing information is more challenging than program-controlled environments.

Furthermore, other researchers have indicated that novices report not knowing where they have been in the hypermedia or where they should go (i.e., disorientation; Last, O'Donnell, & Kelly, 2001). As a result, learners have been found to stop navigating too soon, have difficulty planning and executing direct routes to desired information, take longer to search for information, miss sections of text entirely, or repeatedly revisit sections (McDonald & Stevenson, 1996, 1998). Although the researchers used closed hypermedia rather than the Internet itself, the results suggest that having to select information to access and decide the order in which to read the content when navigating the Internet will have negative implications for learning when domain knowledge is low (see also Alexander et al., 1994; Dillion & Gabbard, 1998; Fry, 1972; Gall & Hannafin, 1994).

In addition to the lack of structure and organization, the Internet is dynamic and constantly changing, with webpages appearing, changing and disappearing unpredictably. Therefore, resources that less knowledgeable learners may be comfortable with or have become familiar with during their searches may not be available during subsequent searches. Learners must then begin searching the Internet for resources all over again. Finally, the Internet is missing a critical editor – no reviewer, agency or governing body is responsible for screening the quality of material and evaluating the content in terms of bias, accuracy and accessibility of the material for readers at different levels of literacy (Schacter, Chung & Dorr, 1998). This may be a particularly challenging problem for novices, as they likely would not be able to determine whether the information presented is valid.

Moreover, without a critical editor to evaluate the format of websites, multimedia presentation on the Internet may be arranged in a manner that increases extraneous cognitive load. For example, the Internet has the potential to present learners with multimedia, which has been found to facilitate learning for novices in comparison to text-only presentations (Mayer, 1989; Mayer & Anderson, 1991; 1992; Mayer & Gallini, 1990). Specifically, webpages on the Internet vary in their combination of text, illustrations, animation and narration, and as such may be considered a collection of individual multimedia presentations. The presentation of pictures and corresponding text, however, may impose higher cognitive demands if the presentation is poorly designed. First, when using the Internet, webpages typically are not short enough to present all information on a single screen. Instead, learners must scroll down the screen to be able to view all the information. This format increases the probability that corresponding pictures and text will be separated on the screen, causing learners to scroll back and forth between the information.

The contiguity effect (or split-attention effect) states that learning is enhanced when pictures and related text are presented near each other rather than far away on a screen or a page (Mayer, 2003). The physical integration of pieces of information which are otherwise incomprehensible in isolation has been suggested to reduce unnecessary mental effort (Kalyuga, Ayres, Chandler & Sweller, 2003). To investigate the contiguity effect, Kalyuga and colleagues (1999) investigated subjective difficulty ratings associated with instructions that included diagrams plus either audio explanations or printed text instructions on a computer screen. The inclusion of printed text required learners to jump back-and-forth (or split their attention) between the picture and text to understand the information. In contrast, the use of audio in place of printed text allowed learners to maintain attention on the diagram while listening to a verbal explanation. Difficulty ratings and performance scores indicated that participants found it more challenging to learn information when they needed to jump back-and-forth between information (see also Chandler & Sweller, 1996; Kablan & Erden, 2008; McCrudden, Schraw, Hartley & Kenneth, 2004).

Similar findings have resulted from hypermedia studies including the dual-task paradigm. Wastlund, Norlander and Archer (2008), for example, had participants study from hypermedia that either had information formatted to fit the computer screen or required participants to scroll down the page to view the entire sections. During the learning session, participants were also required to complete a secondary task. The comparison of dual-task performance between the fitted text and the scrolled text provided information on the mental load associated with the separation of information. Reaction times to a secondary task were faster when information was formatted for the computer screen compared to when learners needed to scroll down to view the content. These findings suggest that mental demands are reduced when learners do not have to hold information from earlier passages in their working memory to understand subsequent content (Wastlund et al., 2008). Findings from performance observations also indicate that mental workload is increased when attention is split between information (e.g., Mayer & Anderson, 1991, 1992; Moreno & Mayer, 1999). The separation of information on the computer screen, either through scrolling or the selection of another webpage, then may make learning from the Internet challenging.

The unique features associated with the Internet, therefore, may impose high mental demands on the learner and may give rise to difficulties in recall performance (Lidstone & Lucas, 1998). According to Foltz (1996), because domain knowledge is central to comprehension, a lack of domain knowledge may lead to even greater comprehension problems with hypertext than with linear text. Indeed, some researchers have found that learners do not benefit from searching for information on the Internet in comparison to a control group when domain knowledge is low. For example, Willoughby and colleagues (2009) asked participants to complete a written assignment corresponding to a low knowledge domain. While some participants were able to search the Internet for information prior to completing the task, the remaining learners completed the assignment without access to the Internet. Surprisingly, there was no difference in subsequent recall performance among these two groups, suggesting that low domain knowledge appears to be an important barrier to successful learning with the Internet (also see Lawless, Schrader & Mayall, 2006).

However, hypermedia research has its limitations for addressing the basis of individual differences in novices' success when learning from the Internet. First, although some researchers did take into account domain knowledge, they typically compared performance between low and high knowledge participants, or they compared outcomes among novices as a function of condition. Thus, each group's *average* achievement has been reported. This methodology provides an investigation of differences in achievement within a particular learning environment depending on domain knowledge, or which learning environment results in higher achievement among novices. Such research, however, does not provide information regarding whether there are differences in achievement among learners with the same level of domain knowledge who navigate the same environment. In addition, they do not contribute to an understanding of why some learners are more successful than others. Thus, we do not know whether some novices spend more time studying relevant information or make adjustments to their invested mental effort more so than their peers, and if these factors account for variability in achievement. Such information is essential to further understand the behavioral processes involved in successful learning and to develop appropriate supports for when individuals guide their own learning within complex learning environments such as the Internet.

Second, the majority of research examining achievement outcomes after interacting with a hypermedia environment has rarely used the Internet. Instead, researchers typically required participants to search within a closed hypermedia environment (e.g., Balcytiene, 1999; Calisir & Gurel, 2003; Lawless & Kulikowich, 1996; Lawless, Mills, & Brown,2002; McDonald & Stevenson, 1998) or to watch a short multimedia presentation (e.g., Brunken, Plass, & Leutner, 2004; Mayer & Anderson, 1992; Moreno & Mayer, 1999). Unlike the Internet, closed hypermedia is comprised of a fixed amount of reliable information, usually available in the form of educational computer software (e.g., Encarta) or electronic databases (e.g., PsycINFO or online library catalogs). In comparison to the Internet, closed hypermedia is typically comprised of much less information, limits how far learners may travel away from the main page, contains fewer hyperlinks in general, hierarchically organizes information, provides an overview of the information allowing learners to know where they are in the system at all times, and contains less extraneous information. It is not clear then whether navigation behaviours in closed hypermedia would extend to the Internet. Therefore, research focusing on how novices guide their learning when using the Internet without restrictions is essential.

Exploring Time Spent with Relevant Information, Mental Effort, and Achievement

The main goal of the current study is to account for variability in achievement among novices when learning from complex learning environments such as the Internet. The following is a discussion of how time spent with relevant information may directly predict achievement and mediate the relation between invested mental effort and achievement.

Does time spent with relevant information predict achievement? Before learners can attempt to comprehend content, they must actively select relevant information from the accessed material, which requires distinguishing between goal-relevant and extraneous information. However, novices have a tendency to use inferior techniques when trying to separate relevant and irrelevant information. Researchers have found that novices have difficulty finding a correct answer even when scanning pages of information that contain the relevant information (Symons & Pressley, 1993). Moreover, when using hypermedia, Marchionini, Dwiggins, Katz, and Lin (1993) found that eight novice adults typically judged the relevancy of full-text articles based on the type and date of the article, the nationality of the author, the comprehensiveness of the title and whether the title contained key terms. On the other hand, experts used more appropriate strategies such as judging whether or not the information addressed the question at hand (Marchionini et al., 1993). Because only the average frequency of behaviours were reported in these studies, however, it is not clear if some of the novice learners were able to identify relevant information or judged the material based on whether it addressed the assigned question.

Some researchers have started to explore learners' navigations within a hypermedia environment, and the relation between time spent with relevant information and achievement on recall tests. For example, Lawless and Kulikowich (1996) investigated the navigation behaviours of 42 undergraduate students who had varying levels of domain knowledge while they studied information from a closed hypermedia resource. Lawless and Kulikowich reported individual differences in the frequency of navigation behaviours across learners. Based on this, they created three clusters of navigators - knowledge seekers, feature explorers and apathetic hypertext users. First, feature explorers, containing a majority of the participants, had below average standard scores for the amount of time they spent on the content of the hypermedia (relevant information). Comparing the proportion of time spent on the content in comparison to the time spent with the special features (extraneous stimuli), researchers suggested that these individuals invested their time seeing what kinds of screens were contained within the hypermedia. In contrast, knowledge seekers had above average standard scores on the amount of time they spent with the content of the hypermedia. Finally, the third cluster represented the learners who were below average on time spent with the content. This group referred to as apathetic hypertext users appeared not to care about exploring or gathering information in the hypermedia.

Lawless and Kulikowich (1996) examined whether the three navigation clusters differed in domain knowledge (measured by a pretest) and recall performance. Knowledge seekers scored the highest in domain knowledge, followed closely by feature explorers and then apathetic hypertext users. A similar pattern emerged when comparing performance outcome scores; however, these differences were not significant. Nevertheless, there was large variability in domain knowledge scores within each of the groups, suggesting that there were differences in learners' navigation styles among novice learners. Some novices would have been classified as knowledge seekers, and may have spent more time spent with relevant information than novices classified as feature explorers or apathetic hypertext users. Although these navigation clusters may not extend to the Internet because of the differences between closed hypermedia and the Internet, the results suggest that some novice learners may spend more time with relevant information than their peers.

More recently, however, closed hypermedia researchers have examined directly the proportion of time spent with relevant information and achievement. Lawless and colleagues (2003) recorded the time spent on relevant nodes (pages) within a closed hypermedia environment. Not surprisingly, they found that a greater proportion of time spent with relevant information facilitated recall. However, all the information contained on one node was considered either relevant or extraneous. Judging the relevancy of information in this situation was likely less challenging than if relevant and extraneous information were intermixed on a page, which is often the case with webpages on the Internet. The amalgamation of goal-relevant and irrelevant information may also increase the probability of becoming distracted. Researchers, however, have yet to examine whether novices differ in the amount of time they spend with relevant information when learners are exposed to both relevant and extraneous content on a single page in an open-ended environment such as the Internet.

When sorting through various webpages, learners must decide whether they will stay on a particular webpage, continue searching for a new source, or return to a previously viewed webpage. Therefore, time spent with relevant information consists of both initial visits and revisiting content. While some researchers have regarded novices' revisitation of content as a marker for disorientation (e.g., McDonald & Stevenson, 1998), others have indicated that this action may facilitate learning. Researchers have identified that repetitive reading can be an effective study strategy and facilities comprehension in comparison to a single reading of a passage. For example, Haenggi and Perfetti (1992) compared the learning outcomes of undergraduate students who rewrote notes, reviewed notes or reread the text. During the first session, participants read an eight-page document and were instructed to either record notes or not to record notes, and then completed one version of a multiple-choice test. Participants returned one day later for a second session when they restudied the material. Of the learners who recorded notes, half were instructed to reread their notes whereas the remaining note-takers rewrote their notes. Learners who did not record notes during the first session were instructed to reread the document. After controlling for domain knowledge, learners' comprehension did not differ significantly across the three study strategies on a second version of the multiple choice exam. However, there was a main effect of session such that test scores improved from the first to the second test. Haenggi and Perfetti (1992) concluded that repetitive reading was an efficient reprocessing strategy, in comparison to single reading (see also Barnett & Seefeldt, 1989; Howe & Singer, 1975). This finding must be interpreted with caution since it cannot be concluded with certainty that the improvements observed were not due to testing effects. The completion of the first multiple choice exam may have guided learners' studying when they returned to the second session. When using the Internet revisiting information may facilitate comprehension for less knowledgeable learners and this is worth exploring.

Hypermedia navigations have typically been observed using log files (Lawless & Kulikowich, 1996), or think aloud procedures (Azevedo, Guthrie, & Seibert, 2004). Log files record learners' actions during navigations, including mouse and keyboard clicks. This technique is valuable for identifying the total number of pages accessed, the sequence of pages accessed and the time spent per page. This technique does not have the capability to distinguish between attended and unattended content within a particular page. On the other hand, the think aloud procedure requires learners to verbalize their actions and cognitive processes during navigations, and thus has the ability to identify passages learners attended to during the learning session. However, this technique may interfere with the natural navigation of the Internet. An objective and unobtrusive methodology that is suited for studying behavioral processes when learning from the Internet is eye tracking. Eye movement data provides information on the content attended to within a particular webpage without disrupting learners' navigations, and thus researchers have the capability to measure the time spent with relevant versus extraneous information within webpages that learners have studied. Therefore, in studies such as the current one, eye tracking can provide novel and valuable information about individual differences in Internet navigations.

In summary, navigating the Internet requires learners to take an active role in their learning. They must search for and identify information pertinent to the task at hand. Only after recognizing relevant content may learners then try to form a coherent mental model and integrate the material into long-term memory. Thus, a greater time spent with relevant information, including initial and subsequent visits, may facilitate learning. The current study will directly explore the relation between time spent with relevant information and achievement among novices when using the Internet.

Does time spent with relevant information mediate the relation between invested mental effort and achievement? Another important aspect for acquiring knowledge is mental effort. Mental effort has been defined as how hard learners try to complete the task-at-hand or task involvement; in other words, the cognitive resources allocated to meet the demands imposed by the task (Paas, Tuovin, van Merrienboer, & Darabi, 2005; Paas & van Merrienboer, 1994). Typically, task involvement has been positively associated with achievement scores, such that for a particular task, novices who invest higher levels of mental effort perform better than their less involved peers

(Hassenzahl & Ullrich, 2007; Paas et al., 2005; Paas & Van Merrienboer, 1994). For example, Muller, Sharma, and Reimann (2008) indicated that learners who reported investing higher levels of mental effort also scored higher on a post-test after watching a multimedia presentation than learners who invest lower levels of mental effort (see also Corbalan, Kester, & van Merrienboer, 2008). Therefore, in tasks where the cognitive demands placed on the learner can fluctuate (such as learning from the Internet), novice learners who engage in more effortful processing when necessary may also perform better on performance measures than their peers who do not increase their effort to meet such demands. The frequency of increases in mental effort within a task may be positively associated with achievement.

Increases in mental effort may facilitate achievement. First, Salomon (1983) indicated that increased mental effort is associated with the creation of strong connections among schema, which facilitates the retention and recall of information. Second, increases in mental effort have been conceptualized as an increase in the amount of resources allocated to the task-at-hand (Paas & Van Merrienboer, 1994). When the task involves learning about a particular topic, resources may be devoted to studying relevant information. Similar to attention, higher levels of mental effort may keep learners on-task, increasing the time spent with relevant information. Therefore, time spent with relevant information may partially mediate the relation between changes in mental effort and achievement.

There are currently a variety of approaches available to assess mental effort including behavioural and physiological measures (see Brunken, Plass, & Leutner, 2003; Paas, Tuovinen, Tabbers, & Van Gerven, 2003 for reviews). Behavioral assessments, such as subjective ratings, may provide an insight into overall level of mental effort. Researchers who rely on subjective ratings of mental effort assume that individuals are able to introspect on the amount of mental effort they invested in the task and associate it with a numerical rating. Given the relative convenience of this method, it is not surprising that subjective ratings have been commonly used across various domains of research (e.g., Paas, 1992; Paas et al., 2003). Furthermore, researchers have also developed scales to assess the level of invested mental effort that involve multiple questions, such as the Subjective Workload Assessment Technique (SWAT; Reid & Nygren, 1988).

Physiological measures, on the other hand, have the potential to provide information regarding momentary changes in effort, particularly increases, *within* participants for a particular task. Physiological techniques are based on the assumption that changes in physiological variables, such as heart rate and eye activity, capture changes in mental effort (Paas et al., 2003). Of particular interest in the current study are pupillary changes. Pupillary dilation seems to be a highly sensitive measure for tracking fluctuations in mental resources both within and between tasks (Paas et al., 2003) and has been associated with changes in mental effort (Beatty & Lucero-Wagoner, 2000). Beatty (1982) conducted a meta-analysis of the literature that included pupil diameter as a measure of mental effort and found that the research was fairly coherent. Across a variety of studies, pupil dilation appeared to be an indicator of increases in effort expended due to the demands of the task. For example, Wright and Kahneman (1971) explored pupil dilation in a sentence-processing task. Learners were presented with complex sentences and instructed to either recall the sentence or answer a comprehension question. During the recall trials, learners were required to read the statement and then wait 3 or 7 sec (i.e., retention interval) before recall. Pupil dilation tended to peak during the retention interval, suggesting that during this task holding information in working memory required the greatest investment of mental resources. Similarly, for the question trials, learners read the statement and question and then paused before providing an answer. Peak dilation occurred during the pause, which researchers indicated represented the mental effort associated with formulating an answer.

Kahneman and Beatty (1966) found similar evidence that pupil dilation is an indicator of invested mental effort by using an auditory serial span task. Pupil dilation was measured during the common digit span task for strings of three to seven digits. Pupil diameter systematically increased in size with each digit presentation, peaked between presentation and recall, and declined after recall. Moreover, peak diameter increased as the size of string increased. Peavler (1974) also found that pupil diameter increased with the presentation of digits to-be-recalled. More interestingly, however, Peavler found that pupil diameter only increased until a maximum digit span (about seven or eight items) was reached. In other words, pupillary-response was similar for digits that were presented as the seventh through thirteenth positions. Therefore, the exceeding of mental resources may be illustrated by a steadily increase in pupil diameter followed by a plateau. On the other hand, Granholm, Morris, Sarkin, Asarnow and Jeste (1997) reported that following cognitive overload using the same digit span task (around approximately the seventh digit in the span), pupil diameter decreased from maximum. Granholm and colleagues suggested that the difference in results may be due to differences in instructions. Where Peavler informed learners that some strings would be too long to remember, Granholm and colleagues did not include this warning. Thus, in the former study learners may have employed strategies to maintain the first seven or so digits and ignored the remaining. In either case, the peak pupil diameter still represented when maximum resources were being invested in processing.

In contrast, Schultheis and Jameson (2004) indicated that pupil size may not be a suitable measure of mental effort when using hypermedia. Specifically, 13 adults read four easy and four difficult texts presented on a computer screen. The mean number of words read per second, subjective ratings of perceived load experienced, event-related brain potentials and pupil dilation were recorded while learners read the passages. Reading speed, subjective load ratings and event-related brain potentials indicated greater effort when reading difficult texts in comparison to a more simple text passage. However, the results pertaining to pupil diameter were less clear. For six participants, the difficult texts were associated with increases in pupil diameters, whereas researchers observed the opposite relation for the remaining adults. According to Granholm and colleagues' (1997) results, however, the decreases in pupil diameters for the difficult text may have been due to cognitive overload. Therefore, changes in pupil diameter as an indicator of momentary mental resources while searching the Internet may be promising, and were included in the current study.

Predicting Variability in Time Spent with Relevant Information and Mental Effort

Researchers have suggested that individuals vary widely in how they search hypermedia (Lawless et al., 2003; Willoughby et al., 2009). While there have been studies exploring differences in learners' navigations in hypermedia, we still know relatively little about how navigation relates to novices' learning - specifically, what behaviours facilitate spending more time with relevant information. In addition, researchers have suggested that characteristics of the learner, including self-regulated learning characteristics and cognitive factors, may influence experiences with the Internet and invested mental effort (Button, Mathieu, & Zajac, 1996; Forster & Nilli, 2008; Lee & Tedder, 2003; Liu & Reed, 1994). The following then is a discussion of navigation behaviours and learner-related factors that may predict time spent with relevant information when novices navigate the Internet, in addition to the learner characteristics that may account for variability in effort expenditure.

Do navigation behaviours predict time spent with relevant information? To acquire knowledge regarding a topic, one must first obtain a resource containing the desired information, which when using the Internet may be accessed in a variety of ways. Four methods of retrieving information include clicking on a topic presented in an index (i.e., browsing), going directly to the desired website by entering its URL or web address (e.g., http://www.wikipedia.ca), clicking on a hyperlink within the website which would take learners either to a page within the current website or to a different website entirely, or using search engines (Kuiper, Volman & Terwel, 2005). The majority of Internet users frequently rely on one or more of the many search engines available, such as Google or Yahoo, to retrieve information corresponding to a topic (Lorenzen, 2001). These search engines may provide learners with seemingly different results. That is, they may consist of a majority of the same webpages but present them in different sequence such that webpages appearing on the first page in Google may be on a subsequent page in Yahoo (or vice versa). On the one hand, the common resources across search engines may result in revisiting webpages or provide additional quality resources. Alternatively, having to sort through another list of possible webpages may be time consuming, which when under time restrictions can be hindering as it takes time away from studying. It is unclear then whether the number of search engines used impacts the time spent with relevant information, and if so if this is in a negative or positive way. The current study investigated this issue.

Once deciding on a search engine, learners input keywords related to their search topic and are provided with a list of websites containing the specified term(s), also known as hits, which may or may not be relevant to the desired topic. This list typically contains hundreds of thousands or even millions of websites, which may vary depending upon the search engine used. Also, they may change daily when using the same search engine due to the constant changes, deletions, or additions of websites. Not only has it been suggested that the quality of the search is positively related to the quality of results, but novices typically use inefficient search strategies. Unlike experts, novices may not be aware of major concepts and vocabulary within their domain (Marchionini, 1995); therefore, novices may not be able to generate appropriate or effective search terms, resulting in a high frequency of irrelevant webpages.

Other researchers, however, have found that retrieving relevant resources may not be such a challenging task for novices. For example, Allen (1991) investigated the relation between the quality of search terms and existing domain knowledge. After reading an article on Voyager 2's encounter with Neptune and completing an interpolation task, high and low knowledgeable participants were instructed to search an online library catalog. Their task was to create a list of books that they would want to use to write a detailed article on Voyager 2's encounter with Neptune. The quality of their searches was assessed by how many citations on the participants' list matched the 50 books that two expert reference librarians would request if they completed the task. Surprisingly, learners were able to identify the same amount of relevant books regardless of existing domain knowledge. In fact, less knowledgeable learners conducted searches as effective as highly knowledgeable students; in other words, experts and novices used similar search terms when using an online library catalog (Allen, 1991). In addition, Willoughby et al. (2009) reported great variability in novices' search terms and suggested that novices tend to be successful in the retrieval of quality resources. Although novices generally may produce searches which provide them with relevant information, it is still unknown how the number of searches generated may impact on time spent with relevant information.

Once presented with various potential webpages, learners select and decide which one or ones would facilitate learning of the topic. Researchers have reported variability in the number of nodes or pages less knowledgeable learners opened during their searches in closed hypermedia and the Internet (Calisir & Gurel, 2003; McDonald & Stevenson, 1998; Willoughby et al., 2009). For example, Willoughby and colleagues (2009) reported that one novice accessed 111 webpages, whereas another viewed 36. Similarly, Calisir and Gurel (2003) compared the performance of 15 low and 15 high knowledge undergraduate students as a function of the number of nodes opened in a closed hypermedia program. Recall performance did not differ depending on the number of nodes accessed, for both high and low knowledge learners. Considering, however, that both studies included a very small sample in their analyses (i.e., 20 and 15 novices, respectively), the lack of significant effect may be due to low power and high variability. Therefore, it is important to investigate whether the number of webpages accessed is related to achievement indirectly; specifically, whether the number of webpages is related to time spent with relevant information.

After identifying one or more relevant webpages, learners may want to maintain access to a particular webpage while navigating alternate pages. They may return to webpages accessed earlier in their study session by using the back button, or the history list. However, one of the features offered by the Internet is to open multiple windows simultaneously. This feature enables learners to maintain the original webpage in one window while continuing navigation in another window. Thus, learners may retain access to multiple relevant webpages and alternate between them. This technique may facilitate time spent with relevant information and avoidance of irrelevant webpages.

In summary, researchers have indicated that there is great variability in how learners guide their own learning within hypermedia learning environments. However, the relation between navigation behaviours and time spent with relevant information, a crucial component of developing a coherent mental model when learning from the Internet, has yet to be explored. In the current study, I investigated the relation between time spent with relevant information and the following navigation behaviours: the number of search engines used, the number of specific and general searches conducted, the proportion of relevant webpages accessed, and the maximum number of windows opened simultaneously.

Do learner-related factors predict time spent with relevant information and mental effort? Current university students have typically grown up with computers, with the Internet being commonplace (see Jones, 2002). With such familiarity with the Internet in general, learners may have become comfortable navigating the Internet in a specific fashion. Learner-related factors may account for success when navigating the Internet. In addition, some people may simply be more willing to work hard when learning from the Internet, a challenging resource.

Self-regulated learning characteristics. Self-regulated learning involves actively directing behaviour or strategies to achieve self-set goals (Corno, 1993; Winne & Hadwin, 1998; Zimmerman, 1998). Therefore, the main components to regulating learning involve the setting and pursuit of a goal. In terms of setting goals, strategic learners typically adopt an intrinsic goal orientation. Specifically, they have a tendency to complete tasks for reasons such as to be challenged, to satisfy their curiosity, or to master the content. By placing value in the task itself, strategic learners are more likely to maintain the pursuit of their goal through the use of a variety of strategies (Wolters, 1998). Completion of the task also requires learners to persist when faced with difficult material or uninteresting tasks, referred to as regulating effort. Zimmerman (1989) indicated that strategic learners more readily engage in, provide effort for, and persist longer at tasks than naïve learners. It is not surprising then that more skilled learners recall more information after studying from closed hypermedia in comparison to their less skilled peers (McManus, 2000).

Although as domain knowledge increases, regulating learning becomes more effective, there may be some novices who are more strategic in general than their peers and thereby outperform their peers even when their domain knowledge is low. Wolters and Pintrich (1998) examined the correlation among motivation and strategy use variables for 545 junior high adolescents. Participants were presented with a list of different facets of motivation (task value, self-efficacy, test anxiety) and cognitive and self-regulatory strategy use. The participants provided a rating for the degree to which each statement represented them in three different subject areas, including mathematics, English and social studies. These different variables were highly correlated with one another across the different class subjects, indicating that learners who had strong self-regulatory skills in one subject tended to also exhibit such skills in other subjects, arguing for a domain-general ability.

Some learners, therefore, may be better able to regulate their learning in general in comparison to their peers when domain knowledge is low. Adopting an intrinsic goal orientation and proficiency for regulating effort may be especially important when navigating the Internet. Learners are responsible for retrieving sources of information, deciding what resources to use, choosing the order of the webpages as well as the pacing of their learning, and determining whether the information meets the goals of the task. Given this, more skillful learners may be better able to meet such challenges and thus spend more time with relevant information than less skilled learners. In addition, due to a tendency to adopt an intrinsic goal orientation and a high persistence to learn in spite of challenges, such as boredom or difficulties, strategic learners may meet the challenges associated with the Internet by increasing their effort when necessary. Therefore, learners who adopt a general intrinsic goal orientation may exhibit a greater frequency of increases in mental effort in comparison to less skilled peers. Indeed, Fisher and Ford (1998) indicated that effort expenditure is driven by goal orientations. Moreover, learners who have adopted an intrinsic goal orientation are said to direct attention to the task and devote greater effort to learning than learners without an intrinsic goal orientation (Button et al., 1996).

Cognitive factors. Time spent with relevant information and the frequency of increases in mental effort may be affected by various cognitive factors, including cognitive style, working memory (WM) control, and distractibility. First, learners may differ in the manner in which they mentally organize information, also known as cognitive style. Cognitive style is regarded as a preferred and habitual approach to the way learners process and represent incoming information (Chen & Macredie, 2002; Mayer & Massa, 2003; Riding & Sadler-Smith, 1992; Riding & Watts, 1997). Witkin's field dependent/independent dimension (Witkin, Moore, Goodenough, & Cox, 1977) is the most recognized cognitive style (Thompson & Melancon, 1987). Learners classified as relatively field independent tend to impose their own structure on information, favor the hypothesis-testing approach, and enjoy independent learning opportunities (Ford & Chen, 2001). Typically, such learners comprehend the details before combining them to form a larger mental representation (Pillay, 1998). Field dependent learners, on the other hand, are more global in their perceptions. They tend to organize information into an overall picture of the given information, are less successful at analytic activities, and perform better on learning tasks where information is structured for them (Ford & Chen, 2001). While learners scoring higher on field independent are likely to develop self-defined goals and to be intrinsically motivated, field dependent individuals tend to be extrinsically motivated and require externally defined goals (Witkin et al., 1977).

Learners may be more successful learning from resources that present information in a way that compliments their preferences for structure. Indeed, Weller, Repman, Lan, and Rooze (1995) found that among 33 eighth-grade students, field independent learners outperformed their field dependent peers on posttests after studying information from a hypermedia environment. Learners were assumed to be novices in the topic since they had not yet learned the information in class. Douglas and Riding (1993) found that when structure was imposed on a hypermedia learning situation, such that titles were presented before a passage, field dependent learners were supported whereas there was no effect for field independent individuals (see also Riding & Sadler-Smith, 1992). Therefore, within nonlinear hypermedia which forces learners to self-sequence information, field independent learners may be at an advantage.

More importantly, however, cognitive style may influence the way learners interact with their learning environment. According to Liu and Reed (1994), although field independent and dependent learners performed equally on learning measures after searching a closed hypermedia program, they approached the task very differently. As expected, field independent learners more often jumped around during hypermedia searches than field dependent individuals, and reported feeling lost or disoriented less often. Field dependent learners, on the other hand, typically followed the sequence provided by the program instead of navigating nonlinearly, and preferred interacting with menus to guide their learning (see also Weller et al., 1995). Researchers, however, have not examined whether there are differences in the time spent with relevant information as a function of cognitive style. Given that field independent learners may be more efficient navigating an open-ended environment this cognitive style might facilitate time spent with relevant information when using the Internet. In addition, taking into account that the Internet is suggested to match the learning preferences of field-independent learners, they may put forth the effort necessary to learn from the Internet, showing a greater frequency of increases in mental effort than field-dependent learners.

Second, when navigating the Internet, learners must select and integrate relevant information, both within and across various webpages, while ignoring distracting material. The integration of information requires holding information in WM while formulating a coherent mental model of the novel information and integrating this model with prior knowledge. For complex tasks, such as learning from the Internet, the limitations of WM may create challenges for the learner. WM is a combination of short-term memory storage and controlled attention (Kane & Engle, 2003) and has a fixed pool of mental resources for the processing of attended-to-information and the storage of the results of that processing (Baddeley & Hitch, 1974; Engle, Cantor, & Carullo, 1992). The limited amount of mental resources available means that when greater effort is required to process information, fewer resources are available for storage (Baddeley & Hitch, 1974). Therefore, as long as the mental resources required for processing incoming information do not exceed the resources available, learners may benefit from interacting with the Internet.

Individuals vary in their ability to process and store information in WM (Daneman & Merikle, 1996; Yuill, Oakhill & Parkin, 1989). Some researchers view WM control as being fixed and measurable by specific tasks (e.g., Just & Carpenter, 1992). In fact, there is evidence that individual differences in WM control are relatively stable. Klein and Fiss (1999), for example, found a moderate correlation among test-retest measures of WM control. Tests of WM control typically require participants to hold information in memory while they process unrelated information. For example, the Operation Span (OSPAN) task requires individuals to solve mathematical operations while retaining short lists of words (2 to 6) for recall at the end of a block of trials

(Turner & Engle, 1989). The mathematical operations serve as distractions and obstruct one's ability to rehearse the words. The WM control task does include a measure of short-term memory capacity by requiring learners to retain information for a short period of time before recall; but, more importantly, it imposes additional unrelated processing (Kane & Engle, 2003), and therefore, it is also a measure of executive control. Performance on these tests of WM control consistently has been found to contribute to proficiency on a wide range of tasks. For example, WM control positively correlates with text comprehension (Daneman & Carpenter, 1980), performance on recall tests (Bartholomé & Bromme, 2009; Hambrick & Engle, 2002), taking lecture notes (Kiewra & Benton, 1988), and general fluid intelligence (Conway, Cowan, Bunting, Therriault, & Minkoff, 2002). In addition, partialing out shared variability between WM control and short-term memory (typically measured by tasks such as digit span where distractions are not presented and participants simply recall a series of digits) did not have an effect on the correlation between WM control and general fluid intelligence (Conway et al., 2002). This finding supports Engle's (2002) claim that greater WM then is more than just a larger capacity for the short-term storage of information; it is also "a result of greater ability to control attention...[and] means greater ability to use attention to avoid distraction" (p. 20).

Researchers have compared performance outcomes as a function of WM control after studying from various hypermedia presentations, although no distinctions between learners were made regarding domain knowledge. For example, Lee and Tedder (2003) had undergraduate students read one of three formats of hypermedia that contained identical information: linear, hierarchical and networked hypermedia. The linear format guided learners through a pre-determined order of pages organized from general to specific ideas. The hierarchical version of the hypermedia program also organized information from general to specific; however, learners were able to click on embedded hyperlinks for additional information regarding a particular sub-topic, and thus had some control over the sequence of the presentation. In contrast, each page in the networked hypermedia contained a list of hyperlinks to all pages in the program, providing learners with ultimate control over the sequence of the information. Thus, the networked format most closely resembled the Internet. Although the results did not reach significance, they were in the expected direction. Specifically, learners with low WM control descriptively recalled the most facts after studying from the linear hypermedia in comparison to the other formats. On the other hand, learners with high WM control recalled a similar number of facts regardless of the hypermedia format. Similarly, using paper-based materials, Budd, Whitney, and Turley (1995) found that learners with low WM control recalled more information after studying from structured texts in comparison to an unstructured version. In contrast, learners with high WM control performed equally regardless of the level of structure. Overall, these findings suggest that learners with low WM control may have difficulty learning from the Internet, a typically unstructured resource.

It is clear that WM control typically facilitates learning. What is less clear is whether there are differences in the amount of time learners spend with relevant information when using the Internet as a function of WM control. According to Engle, Kane, and Tuholski (1999), individual differences in WM control may reflect differences in the ability to stay on task when faced with interfering stimuli. Kaakinen, Hyönä, and

Keenan (2003) suggested that learners with high WM control may be better able to allocate their attention to task-relevant information versus extraneous content in comparison to learners with lower WM control. To my knowledge, hypermedia researchers have not considered this learner characteristic when exploring navigation behaviours specifically. Given the importance for learning, WM control was included as a predictor of time spent with relevant information in the current study.

From the research examining the effects of WM control on learning, however, it is unknown whether WM control is related to increases in mental effort. Individuals with low WM control may need to invest higher levels of mental effort more often than peers with high WM control. In fact, Heitz, Schrock, Payne, and Engle (2008) found that learners with low WM control had larger pupil dilations (greater invested effort) on average for a reading task even though they scored lower in performance for comprehension than their peers with high WM control. Heitz and colleagues concluded that participants low in WM control need to invest higher levels of mental effort than their peers with high WM control during reading. Since reading occurs during learning from any resource, WM should be taken into account as a predictor of invested mental effort when learning from the Internet. However, WM control may not directly predict the frequency of increases in mental effort, which in turn predicts time spent with relevant information. Instead, the frequency of increases in mental effort may interact with WM control when examining time spent with relevant information, such that a greater number of increases in mental effort within a session is particularly important for learners with low WM control.

Finally, when using the Internet, learners likely are exposed to extraneous information, which may be problematic for learners who are highly distractible. Researchers have agreed that learners vary widely in their ability to sustain attention. For example, children with attention deficit disorders and learning disabilities report high levels of distractibility in comparison to control children (e.g., Barkley, Grodzinsky & DuPaul, 1992). Within typical populations, there is variability in susceptibility to distraction (Patton & Offenbach, 1978). High distractibility has been associated with poor cognitive performance (Douglas, 1983) and greater response errors when distracters are present (Patton & Offenbach, 1978). In addition, individuals prone to distraction have been shown to perform more poorly on everyday tasks than individuals who are not prone to distraction (Forster & Nilli, 2008).

Specific to hypermedia, Lawless and colleagues (Lawless & Kulikowich, 1996; Lawless et al., 2003) explored the attention of novices when irrelevant information – in the form of seductive details (interesting but irrelevant information included to increase the interest of learners) – was included in a closed hypermedia environment. The findings indicated that novices have a tendency to become distracted by seductive details, such as sound effects and digitized movies. However, only the average frequencies of behaviours for novice learners were reported in these studies, and not all novices may have attended to the distractions. Similarly, Mayer et al. (2001) and Moreno and Mayer (2000) reported variability for recall performance among learners who were exposed to irrelevant information, suggesting that some novices may have ignored the distractions. Given the distractions present on the Internet, including the seductive details or extraneous content, novices with lower levels of distractibility may be less likely to attend to these than their more distractible peers, leading to a greater time spent with relevant information. Furthermore, distractibility may also contribute to fluctuations in invested mental effort when navigating the Internet. Distractible learners who show a greater frequency of increasing mental effort while navigating the Internet may direct attention to task-relevant information and thus spend more time with relevant information in comparison to distractible learners who exhibit fewer increases in mental effort. However, since less distractible learners may not have difficulty regulating their attention, adjustments in mental effort may not be as important. Therefore, the frequency of increases in mental effort may be particularly important for learners with high distractibility in terms of learning from the Internet, suggesting an interaction between mental effort and distractibility when examining time spent with relevant information.

Current Study

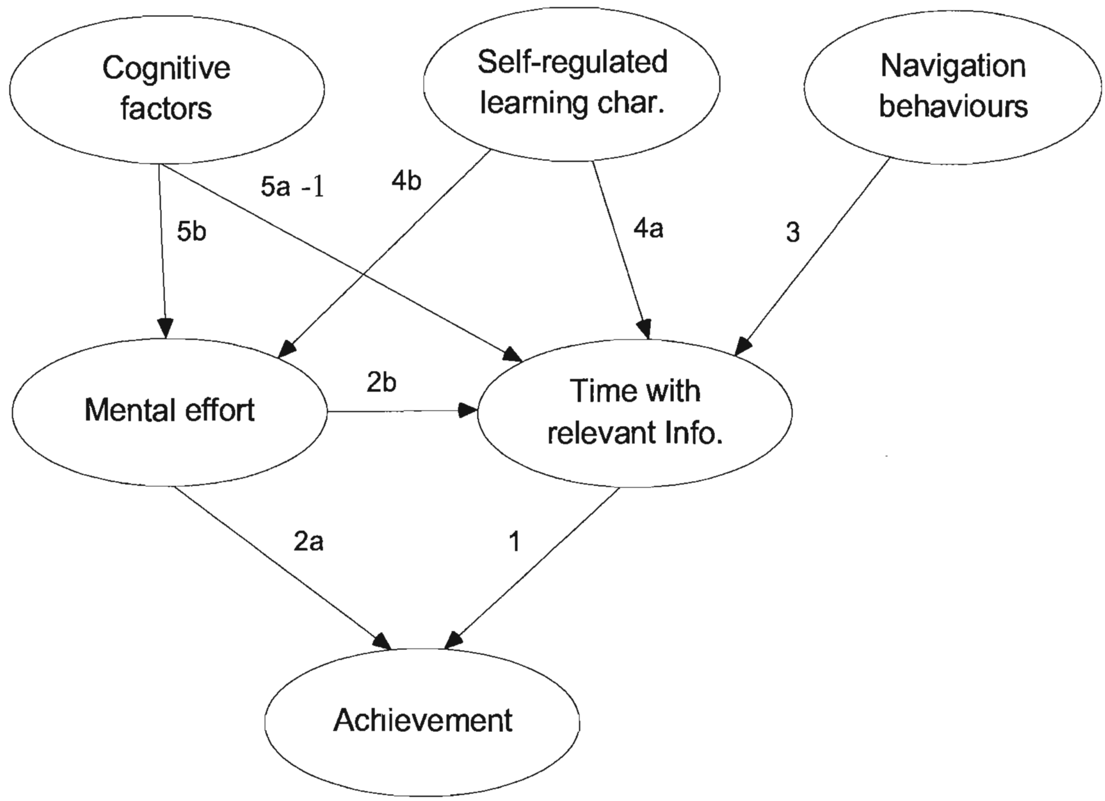
The nonlinear, non-hierarchical structure associated with the Internet may impose high demands on learners, especially when domain knowledge is low. In fact, on average, novices have difficulty learning from the Internet (Lawless et al., 2006; Willoughby et al., 2009). Since Internet use is prevalent among adults any recommendation to limit its use when learners are novices is not useful. Instead, it is essential that we determine appropriate scaffolds for novices when using the Internet. To be able to determine the supports that promote successful learning for novices we must first understand how learners interact with the Internet, specifically whether there is variability in time spent with relevant information or fluctuations in invested mental effort and how these variables contribute to achievement differences. Exploring learners' Internet navigations is a relatively new field of research, and thus little is known about the relation between time spent with relevant information, increases in invested mental effort within a learning session, and achievement. Moreover, it is also unclear what factors may account for variability in time spent with relevant information and changes in effort expenditure when using a complex learning environment such as the Internet. Therefore, to address these issues, the current study explored two general questions: Does time spent with relevant information or frequency of increases in invested mental effort account for variability in achievement among novices when navigating the Internet? If so, which navigation behaviours and learner-related factors may predict time spent with relevant information and frequency of increases in invested mental effort?

Summary of Research Questions and Hypotheses

Given the limited research regarding novices' interactions with the Internet, the following hypotheses (and corresponding analyses) were exploratory in nature. Nonetheless, I did have some predictions regarding the outcomes. Each hypothesis is modeled by means of a Path in Figure 1.

Q1) Does time spent with relevant information predict achievement? Lawless et al. (2003) reported that learners who studied relevant information longer had enhanced recall scores in comparison to their peers who spent less time with relevant information when searching closed hypermedia. Although domain knowledge was not taken into account, it seems likely that these results would extend to novices when searching the Internet. Therefore, it was expected that novices who spent more time studying relevant information would obtain higher achievement scores in comparison to their peers who spent less time studying relevant information (modeled by means of Path 1 in Figure 1).

Q2) Does time spent with relevant information mediate the relation between increases in mental effort and achievement? Researchers have found that learners who indicated investing greater mental effort during a multimedia presentation also scored higher on achievement tests (Corbalan et al., 2008; Muller et al., 2008). It was expected that this pattern would generalize to the Internet (modeled by means of Path 2a in Figure 1). More importantly, increased mental effort may be associated with increases in cognitive resources allocated to the task at hand (Paas & Van Merrienboer, 1994). The frequency of increases in involvement within the task may facilitate the formation of a coherent mental model regarding tropical cyclone formation (the to-be-learned topic) or maintain attention on (or redirect attention toward) goal-relevant information. Therefore, A.



B.

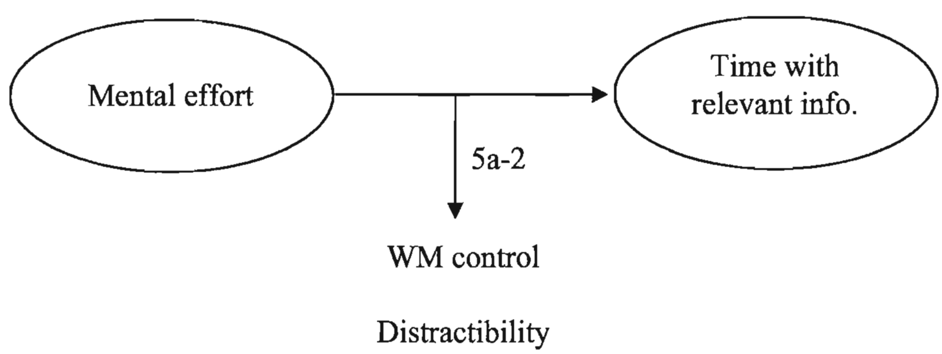


Figure 1. Hypothesized model of the relations among achievement, increases in mental effort, time spent with relevant information, learner characteristics, and navigation behaviours. The names of the paths refer to the hypotheses. The hypothesized direct and indirect effects (A) as well as the moderating effects (B) are shown.

it was expected that time spent with relevant information would be positively related to frequency of increases in mental effort. As time with relevant information was expected to predict achievement, it was hypothesized that a greater frequency of sudden increases in mental effort may be positively related to time spent with relevant information, which in turn would predict achievement. In other words, time spent with relevant information was expected to partially mediate the positive relation between the frequency of increases in mental effort within the learning session and achievement (modeled by means of Paths 2a, and the combination of 2b and 1 in Figure 1).

Q3) Do navigation behaviours account for variability in time spent with relevant information? The current study explored the relation between time spent with relevant information and number of search engines used, number of specific and general searches conducted, the proportion of relevant webpages accessed, and the maximum number of windows opened simultaneously. Given the lack of research in this area, it was unclear as to the relation between time spent with relevant information and these navigation behaviours, with the exception that the greater number of windows opened was expected to be positively related to time spent with relevant information. Opening multiple windows enables learners to maintain easy access to relevant webpages while continuing to navigate in another window. The relation between navigation behaviours and time spent with relevant information is modeled by means of Path 3 in Figure 1.

Q4a) Do self-regulated learning characteristics account for variability in time spent with relevant information? Regulating one's own learning involves actively directing one's behaviour to achieve self-set goals (Winne & Hadwin, 1998). The typical adoption of an intrinsic goal orientation to complete the task despite challenges or boredom is a characteristic of skillful learners and related to high achievement (Hadwin et al., 2001). Based on this general finding, it was hypothesized that a tendency to adopt an intrinsic goal orientation and to regulate effort would be positively related with time studying relevant information (modeled by means of Path 4a in Figure 1).

Q4b) Do self-regulated learning characteristics account for variability in the frequency of increases in mental effort? Learners who typically adopt an intrinsic goal orientation and regulate their effort complete tasks to master the content and pursue their goals in the face of challenging and uninteresting content, respectively. These skilled learners likely try harder to successfully complete a task. In the present study, it was expected that higher scores on the measures of self-regulated learning characteristics would be associated with a greater frequency of increases in mental effort while navigating the Internet (modeled by means of Path 4b in Figure 1).

Q5a) Do cognitive factors account for variability in time spent with relevant information? The following three cognitive factors were explored in the current study: cognitive style, working memory (WM) control, and distractibility. First, there is evidence that learners navigate the Internet differently depending on their cognitive style (e.g., Ford & Chen, 2001; Weller et al., 1995). Field independent learners more often jump around during hypermedia searches and report feeling lost or disoriented less often than field dependent learners. Field dependent learners, on the other hand, typically follow sequences instead of navigating nonlinearly, and prefer interacting with menus to guide their learning. Researchers, however, have not examined whether there are differences in the time spent with relevant information depending on cognitive style. Given that field independent learners may be more efficient navigating an open-ended environment, it was expected that this cognitive style may facilitate time spent with relevant information.

Second, WM control places limitations on the amount of information that can be stored and processed at any one time (Baddeley & Hitch, 1974). There is much evidence that high WM control facilitates learning (e.g., Hambrick & Engle, 2002). However, Heitz and colleagues (2008) suggested that individuals with low WM control may need to invest higher levels of mental effort than their peers with high WM control to be able to perform at similar levels. Therefore, the frequency of increases in mental effort may interact with WM control when examining time spent with relevant information, such that the frequency of increased mental effort is particularly important for learners with low WM control.

Third, some novices become distracted more easily than others in general, which has a negative impact on learning (Patton & Offenbach, 1978). Given the high level of extraneous information learners may be exposed to when navigating the Internet, distractibility may influence the time spent with relevant information. In particular, it was hypothesized that there may be a negative relation between susceptibility to distraction and time spent with relevant information. Similar to predictions related to WM control, a greater frequency of increases in mental effort may be particularly important for learners with high distractibility in terms of learning from the Internet, suggesting an interaction between mental effort and distractibility when examining time spent with relevant information.

The direct relation between the three cognitive factors and time spent with relevant information is modeled by means of Path 5a-1 in Figure 1. The moderating effect of WM control and distractibility for the relation between increases in mental effort and time spent with relevant information is modeled by means of Path 5a-2 in Figure 1.

Q5b) Do cognitive factors account for variability in the frequency of increases in mental effort? The Internet has been regarded as a challenging and complex learning resource. To be able to perform well novices may need to temporarily increase mental effort during their navigation. I explored cognitive style, WM control, and distractibility as predictors of sudden increases in effort expenditure. Because the Internet is typically structured and organized in a manner which complements the way learners classified as field-independent process information (Ford & Chen, 2001), these learners may be more motivated to try hard than learners classified as field-independent and thus more willing to invest greater effort when necessary. Therefore, it was expected that field-independence would be related to a greater frequency of increases in mental effort. In addition, WM control may also impact invested mental effort. Learners with low WM control may have to invest a higher level of mental effort more often than their peers with higher WM control to manage the demands associated with the Internet's nonlinear structure and perform at the same level as learners with high WM control (Heitz et al., 2008). Accordingly, it was expected that learners with high WM control would show fewer increases in mental effort than learners with low WM control. Finally, when navigating the Internet learners are exposed to extraneous information, which is potentially challenging for highly distractible learners (Patton & Offenbach, 1978). Therefore, learners with higher levels of distractibility may need to expend higher levels of effort more often to maintain attention in the face of distractions in comparison to individuals with lower levels of distractibility. Following this, it was predicted that highly distractible individuals would increase mental effort more often in comparison to less distractible learners.

Control Variables

Learners' achievement scores and time spent with relevant information may be positively related to their levels of general mental ability, reading comprehension, existing domain knowledge, Internet experience and overall motivation. Since these factors were not of interest in the proposed study, they were controlled for in all appropriate analyses.

Method

Participants and Design

One hundred and thirty-one undergraduate students who had not completed any courses in Geology or Geography at the post-secondary level were recruited in order to target individuals with little knowledge about how tropical cyclones form (the to-be-learned topic in the current study). Participants were randomly assigned to one of two conditions: (a) navigate the Internet for 20 min prior to completing an assessment of knowledge (i.e., Internet group; $n = 110$), or (b) no Internet navigation prior to completing an assessment of knowledge (i.e., control group, $n = 21$). All participants completed the same achievement test to assess knowledge of how tropical cyclones form (see Appendix B). The control group was included to obtain a baseline measure of domain knowledge among novices before searching the Internet. Participants were informed of which condition they were assigned to when they arrived to complete the study. Participants in the Internet condition received either 3 hours of research participation towards partial fulfillment of course requirement, or 2 hours of research participation plus $15, whereas the control group received 1 hour of research participation or $10.

Due to technical problems associated with Gazetracker or the Internet, data from 85 participants in the Internet group were included in the current study. To ensure that the participants who were excluded from the analyses were equivalent to participants included in the study, univariate analyses were conducted to compare ratings/scores on control variables and the achievement test. The Levene's test for equality of variances was significant for reading comprehension, $F(1, 108) = 4.92$, $p = .029$, and thus equal variances were not assumed. Participants included in the current study ($n = 85$) were not significantly different than learners who were excluded ($n = 25$) on the following variables: reading comprehension, $t(108) = 1.38$, $p = 0.18$; general mental ability, $t(108) = 1.28$, $p = 0.20$; Internet knowledge, $t(108) = 1.06$, $p = 0.29$; overall motivation, $t(108) = 0.75$, $p = 0.45$; and achievement scores, $t(108) = 0.34$, $p = 0.74$. However, the excluded participants did report a significantly higher rating of topic knowledge ($M = 2.72$, $SD = 1.34$, $SE = 0.27$) in comparison to included participants ($M = 2.06$, $SD = 1.18$, $SE = 0.13$), $t(108) = 2.39$, $p = 0.02$. Since the purpose of the current study was to explore *novices'* Internet navigations, the fact that learners with higher self-reported topic knowledge were excluded strengthens rather than weakens the findings.

An equal proportion of males and females were assigned to each condition, χ^2 (1, 1) = .001, $p = .98$. The control condition was comprised of 16 females (76%) and 5 males (23%). Similarly, the Internet condition contained 65 females (76%) and 20 males (23%)[1]. Furthermore, the average age of participants in the Internet and control groups did not differ, $t(104) = .34$, $p = .73$. Table 1 presents descriptive information for participants within each condition.

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[1] Several independent *t*-tests were conducted to explore differences among the variables included in the current study as a function of gender. This was done separately for the Internet and control conditions. See Appendices K and L for tables of means, standard errors, and the results of the *t*-tests.

Table 1

Descriptive Information for Demographic and Control Variables

Scale	Question/Scale	Appendix	Items	Scale Range	*M (SD)* Control	*M (SD)* Internet	Skewness[c]	Kurtosis[c]
Age		C	1	17 +	20.19 (2.79)$_a$	20.46 (3.38)$_a$		
Internet knowledge	How would you rate your level of knowledge for searching the Internet?	C	1	*0* (very low) to *4* (very high)	2.52 (0.60)$_a$	2.49 (0.72)$_a$	0.71	-0.18
Topic knowledge	How would you rate your level of knowledge regarding how tropical cyclones form?	C	1	*1* (very, very low) to *9* (very, very high)	2.24 (1.64)$_a$	2.06 (1.18)$_a$	0.91	-0.08
Overall motivation	What was your level of motivation to complete the tasks you were assigned?	--	1	*1* (very, very low) to *9* (very, very high)	4.98 (1.40)$_a$	7.06 (1.48)$_b$	-0.72	0.62
Reading comprehension[d]	Nelson-Denny reading test (form D) ($\alpha = 0.70$)	G	36	0 to 72	--	36.12 (8.99)	-0.23	0.47
General mental ability[d]	Raven's Progressive Matrices ($\alpha = 0.79$)	H	60	0 to 60	--	49.79 (4.83)	-0.46	-0.07

[a]Values sharing subscript are not significantly different at the 0.05 significance level between the Internet and control conditions. [b]Values with differing subscripts are significantly different at the 0.05 significance level between the Internet and control conditions. [c]Statistics were generated from 85 participants in the Internet condition only. [d]Higher values indicate greater ability.

Materials

Demographic questionnaire. The demographic questionnaire asked participants to report their age, sex, and program/major. In addition, participants rated their level of knowledge and motivation for both using the Internet and tropical cyclones (see Appendix C for the complete questionnaire).

Learner-related factors. Measures pertaining to learner-related factors (self-regulated learning characteristics and cognitive factors) are described in detail below.

Self-regulated learning characteristics. For the current study, I was particularly interested in the intrinsic goal orientation and effort regulation components of self-regulated learning. Therefore, the two subscales of the Motivated Strategies for Learning Questionnaire (MSLQ; Pintrich, Smith, Garcia, & McKeachie, 1993) corresponding to these indices were included in the current study (see Appendix D for the complete questionnaire) [2]. The MSLQ is an assessment of learners' motivational orientations and use of different learning strategies at the post-secondary education level. The questions on the scale are normally worded in a way to assess characteristics within a particular course (e.g., In a class like this, I prefer course material that really challenges me so I can learn new things). The questions were adapted to assess general or average ratings across all courses (e.g., In my classes, I prefer course material that really challenges me so I can learn new things; see Muis, Winne, & Jamieson-Noel, 2007). Therefore, in the current

[2] Both exploratory and confirmatory factor analyses have demonstrated that the MSLQ is comprised of 15 different scales among a college/university population (e.g., test anxiety, task value, self-efficacy, rehearsal and elaboration; Pintrich, 1989; Pintrich & Garcia, 1991). Therefore, it is not appropriate to calculate a total score for the MSLQ. Although only two scales were included in the current study the entire MSLQ was completed as the present study was part of a larger research project.

study these scales are referred to as general intrinsic goal orientation and general effort regulation. Learners indicated how well each statement described them on a 7-point Likert scale (*1 = not at all true of me* to *7 = very true of me*). The entire questionnaire took about 10-20 min for participants to complete.

Scores for the intrinsic goal orientation and effort regulation scales were obtained by calculating a mean across the items. First, the intrinsic goal orientation scale was comprised of 4 items (1, 16, 22, and 24 of the motivation component of the MSLQ), and assessed the reasons why learners engage in academic tasks, on average. Specifically, this scale obtained a measure of the degree to which learners typically participate in tasks for reasons such as to be challenged, out of curiosity, or to master the content. The reported reliability of this scale is 0.74. This level of reliability is not excellent, but is at an acceptable level (Pintrich, Smith, Garcia, & McKeachie, 1991). Second, the effort regulation scale – part of the learning strategies component of the MSLQ – was comprised of 4 items, two which were reverse coded (37r, 48, 60r, and 74). Part of self-regulation is the control of effort and attention when faced with difficult material or uninteresting tasks; in other words, persistence to learn. The reported reliability of this scale is just below acceptable cut-off at 0.69 (Pintrich et al., 1991). However, it has correlated moderately with undergraduate students' final course grades ($r = 0.32$; Pintrich et al., 1993).

Of the three widely used self-report measures for assessing self-regulated learning characteristics (e.g., MSLQ, Learning and Study Strategies Inventory, and Meta-cognitive Awareness Inventory), the MSLQ is the only measure which requires learners to report on intrinsic goal orientation and effort regulation. Moreover, it has good face validity and has been widely used in educational research (e.g., Brookhart & Durkin, 2003; Lodewyk & Winne, 2005).

Cognitive factors. Three cognitive factors were included in the current study: cognitive style, WM control, and distractibility. First, the Group Embedded Figures Test (GEFT; Witkin, Oltman, & Raskin, & Karp, 1971) was administered to classify learners as field dependent/independent. Researchers who have explored the association between cognitive style and navigation behaviours when using closed hypermedia have typically classified learners based on the GEFT (e.g., Chen & Macredie, 2002; Ford & Chen, 2000; Liu & Reed, 1994). Participants were required to trace simple forms in larger complex figures (see Appendix E for an example question from this task). The test consisted of three sections, totaling 25 items. The first section contained seven practice items and the remaining two sections contained nine items each which were used to score cognitive style. Participants were given 12 min to complete the task; 2 min for the practice section and 5 min per each test section. The total score was the number of figures correctly traced in the testing sections, with an upper bound of 18. The national mean score for the GEFT is 11.4, with those scoring below 11.4 considered field dependent, and those scoring above 11.4 classified as field independent. A reliability coefficient of 0.82 has been calculated based on administration of parallel forms of the test (Witkin et al., 1971). In the current study, 34 participants were classified as field dependent and 50 as field independent (1 participant did not complete the task correctly and was excluded from corresponding analyses). However, the GEFT was treated as a continuous variable in all analyses.

Second, to measure WM control, learners completed a version of the operation span (OSPAN) task (Turner & Engle, 1989). Learners were presented with sets of operation word strings [e.g., "(9/3) + 5 = 8? chair"]. After reading the operation and word, participants indicated whether the answer to the operation was "true" or "false" by pressing the Z or M key on the keyboard, respectively[3]. Operation-word sequences were presented in blocks containing 2, 3, 4, 5 and 6 trials. Each block was completed 3 times, resulting in a total of 15 blocks and 60 trials. Following the completion of a block, learners recalled the words from the trials in the correct order. Participants were instructed at the start of the OSPAN task that their recall of the words would only be counted if they correctly answered the operation. The order of the trials within each block and the order of blocks were randomized across participants. The OSPAN score was calculated by identifying the blocks for which learners solved all of the operations correctly, and then summing the number of words that were correctly recalled in the proper position across all blocks; higher scores indicated greater WM control[4]. Previous

[3] Typically, participants read the operation aloud and provide a verbal response in addition to pressing the correct key. Verbalizations ensure that participants are attending to the operations and not rehearsing the to-be-recalled words. The current study was part of a larger study in which participants' heart rate and respiration was also recorded. Since verbalizations would have interfered with these physiological recordings they were omitted.

[4] Researchers have indicated that participants who score less than 85% on the mathematical component of the OSPAN should be excluded from analyses. However, none of the participants in the current study met this cutoff. The mean accuracy was 58.12% (SD = 6.73%). WM control tasks are positively correlated with measures of reading comprehension (Daneman & Merikle, 1996) and general mental ability (Unsworth & Engle, 2005). In the present study, however, the OSPAN was not significantly correlated with the reading comprehension task, $r(109) = .000$, $p = 0.99$ or the Raven's matrices, $r(109) = 0.181$, $p = 0.06$. Despite this, all participants were included in analyses involving the OSPAN. Therefore, findings related to the OSPAN in

research has established that this task is moderately reliable. The OSPAN task has demonstrated both adequate internal reliability (Cronbach's alpha approximately .65-.75; Engle et al., 1992) and good test-retest reliability over a span of 3 months (e.g., .76; Klein & Fiss, 1999). Moreover, the OSPAN task has been widely used to measure WM control (e.g., Conway et al., 2002; Kane & Engle, 2003).

Third, the Attentional Control Scale (ACS; see Appendix F), developed by Derryberry and Reed (2002), was used to measure distractibility. According to Derryberry and Reed, the scale measures a general ability to voluntarily control attention, with three correlated subcomponents: (a) maintaining focus on the task (e.g., "My concentration is good even if there is music in the room around me"), (b) shifting attention between multiple tasks (e.g., "After being distracted or interrupted, I can easily shift my attention back to what I was doing"), and (c) flexible control of thought (e.g., "I can become interested in a new topic very quickly when I need to"). Participants indicated on a 4-point Likert scale (*0 = almost never*, to *3 = always*) how often each of 20 situations occurred. Nine items were reverse coded, and an average across all items was calculated, providing an overall score for distractibility. Higher scores were associated with higher levels of distractibility. It should be noted that the scale normally has been used to measure attentional control, such that higher scores indicated better attentional control or lower distractibility. For the purposes of the current study, the scale was recoded as stated above to reduce confusion.

Researchers have reported good internal consistency ($\alpha = 0.88$; Derryberry & Reed, 2002), and construct validity. Specifically, the ACS has been correlated with

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the present study should be interpreted with caution. Analyses were rerun excluding WM control as a predictor; however, the results remained consistent.

ADHD symptoms (r = -0.593; Wiersema & Roeyers, 2009), where higher scores on the ACS (indicating lower distractibility) were associated with lower levels of inattention problems. In addition, Lonigan and Vasey (2009) reported that the ACS correlated highly with the Persistence/Low Distractibility subscale of the Effortful Control Scale (r = 0.60), which asks such questions as: "Even little things distract me" and "Once I'm involved in a task, nothing can distract me from it".

Post-navigation questionnaire. Participants indicated on a scale from 1 (*very, very low*) to 9 (*very, very high*) the following: (a) how difficult it was to learn how tropical cyclones form from the information accessed on the Internet, (b) how much mental effort was required to learn how tropical cyclones form from the webpages accessed (hereon referred to as subjective overall mental effort), and (c) how difficult it was to find relevant information.

Control variables. Control variables included reading comprehension, general mental ability, Internet knowledge, topic knowledge, and overall motivation.

Reading comprehension. Participants completed a comprehension task (i.e., form D of the Nelson-Denny reading test; Brown, Nelson, & Denny, 1973). This task has been widely used in research to assess learners' level of reading ability (e.g., Maki, Jonas, & Kallod, 1994) and consists of eight expository texts and 36 five-alternative multiple choice questions (see Appendix G). The score pertaining to reading comprehension was calculated by giving 2 points for each correct answer on the multiple choice test and summing the points across all questions. Participants were given a maximum of 15 min to complete the task.

General mental ability. Raven's Progressive Matrices was used to obtain a measure of general mental ability (Raven, 1989). This task has been designed to measure abstract reasoning, independent of language or formal schooling, and thus is considered a measure of Spearman's g (Raven, 1962). In addition to having good reliability (α= .86; Raven, 1958), Raven (1989) reported that this test had been used in over 1,600 published psychological studies by the late 1980s. The test consists of 60 items arranged in five sets of 12 items each. Pictures in each set were arranged in increasing order of difficulty. Each item contained a figure with a missing piece. Participants identified (by circling) which of the provided six or eight images would complete the target pattern. Each set involved a different theme for recognizing the missing piece. A score was calculated by the number of correct responses in 20 minutes. See Appendix H for an example from Raven's Progressive Matrices.

Internet and topic knowledge. As part of the demographic questionnaire (see Appendix C), learners rated their knowledge level for searching the Internet on a 5-point Likert scale (*0 = very low* to 4 = *very high*), and their knowledge regarding how cyclones form (i.e., the to-be-learned topic) on a 9-point scale (*1 = very, very low* to *9 = very, very high*).

Overall motivation. As part of the post-navigation questionnaire, participants rated their level of motivation for completing all the tasks in their session on a 9-point Likert scale (*1= very, very low* to *9 = very, very high*).

Achievement test. The achievement test consisted of various sections including multiple choice, true and false, select all possible answers from a list, and putting statements regarding how a tropical cyclone forms in order (see Appendix B)[5]. For each question, participants were required to provide their answer as well as indicate their level of certainty that their answer was correct (very certain, somewhat certain, or it's a guess). Each question only had one correct answer, and thus a single rater scored the tests. Correct answers were given 1 point, with the exception of the putting statements in order section for which participants could obtain half points. For example, if participants gave certain statements the sequence values of 3 and 4, but they should really be 2 and 3, respectively, they received a half point (or .25 for each number). This acknowledged the correct sequence for those two statements. Overall, the test had an upper bound of 28. The achievement score was the percentage of correct answers (out of 28) for which participants did not guess.

The achievement test was created based on information available to participants on the Internet that could be easily retrieved by using general or specific searches. First, I retrieved a collection of relevant webpages from the first 10 results on google, google images, yahoo, and ask.com corresponding to the following search terms: (a) tropical cyclone formation, (b) tropical cyclones, (c) hurricane formation, and (d) tropical cyclogenesis. Wikipedia was one of the foremost listed pages for all searches and search engines and thus was used as a main resource for creating the achievement test. Based on the webpages collected, I compiled a list of the precursors involved in how tropical cyclones form as well as a detailed description of tropical cyclone formation. Two

[5] A pre-test measure of domain knowledge was considered but not used. Although a pre-test would have assessed the level of learning at an individual level, I did not want to provide learners with any information that could have influenced their information-seeking goals. The primary interest in the current study was individual differences in achievement after navigating the Internet and thus a control group was better suited to assess baseline topic knowledge.

sections on the achievement test focused on each of these concepts (i.e., select all that apply and put the questions in order). The true and false as well as multiple choice questions encompassed various idea units pertaining to tropical cyclone formation which ranged in complexity. Questions which addressed content repeated across a variety of webpages to ensure that the content participants would be tested on would be consistent with the information they would likely be exposed to during their searches.

Gaze-tracking. Gaze-tracking equipment (ASL 6.1) was used to record participants' eye gaze while studying the information from the Internet. The gaze-tracker, which has a resolution of 0.1 degree of visual angle, recorded participants' eye line of gaze with respect to the head. Data included time, x and y position coordinates, as well as horizontal and vertical measures of pupil diameter (in pixels). The pupil is elliptical toward the nasal side, rather than spherical. Since researchers have indicated that it is more appropriate to measure vertical (as opposed to horizontal) pupil diameter (Stern & Dunham, 1990), only the vertical measure of pupil diameter was included in the analyses. In addition, the gaze-tracking software packages (Gazetracker) provided a play-back option of learners' navigations in a video mode. This enabled the identification of the webpages accessed and the information viewed within each webpage. Through the use of Gazetracker, I was able to obtain the amount of time learners spent viewing relevant information (details on this process are described in the Coding of Internet navigations section). Researchers have yet to collect such data and thus have not explored whether difficulty learning from the Internet is associated with the amount of time spent studying essential information, and whether navigations are associated with invested mental effort.

Procedure

All participants were tested individually. Participants were randomly assigned to either the Internet or control group. The procedure pertaining to each of these conditions is detailed below.

Internet condition. The total duration of the study for the Internet group was approximately 3 hours. The following order of tasks remained constant across individuals: (1) demographic questionnaire, (2) operation span (OSPAN) task, (3) 20 min Internet navigation[6], (4) achievement test, (5) learner characteristics questionnaires (including the ACS and MSLQ), (6) Raven's Progressive Matrices, (7) Group Embedded Figures Test (GEFT), (8) Nelson-Denny reading comprehension, and (9) post-navigation questionnaire. Learners were equipped with the eye-tracker during the OSPAN task and Internet navigation. For the Internet navigation, participants were assigned to navigate the Internet for 20 min to learn about how tropical cyclones form. All participants were presented with the Internet opened to the same website (i.e., www.brocku.ca) and were free to navigate the Internet without any restrictions. Given that Desjarlais and Willoughby (2007) found that note-taking while studying the Internet did not facilitate performance on an immediate achievement test, participants in the current study were not

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[6] The 20 min time restriction for participants' Internet navigations was chosen for three main reasons. First, researchers have observed great variability in novices' learning outcomes and navigation behaviours when searching the Internet for 20 min (e.g., Willoughby et al., 2009). Therefore, 20 min was sufficient time to observe differences in navigations that may be due to various learner characteristics. Second, Willoughby et al. reported no significant differences in achievement scores between novices in the Internet group and a control group. The primary interest in the current study was to determine why some novices were more successful than others and thus it was important to include a search time consistent with previous research. Third, I wanted to avoid disengagement from the task which may occur during long searches (e.g., 60 min), and 20 min seemed to meet this criterion.

provided with the option of taking notes. In addition, the exclusion of note-taking eliminated a diversion of eye gaze away from the computer screen. Students were provided with the following instructions, "You will be given 20 min to study the information on the Internet. There are no restrictions on your navigations of the Internet. At the same time, you will be wearing an eye-tracking device. The eye-tracking device will record your eye movements during your Internet navigation and what you are doing on the Internet. I will stop your studying after 20 min and the Internet will be closed. You will then be given as much time as necessary to complete a test of what you have learned. I will be available during your entire session if you have any questions regarding the expectations of the assignment or the programs. I am not able to answer questions corresponding to the content of the websites. I will also be monitoring the eye-tracking equipment to make sure that it is recording properly. Do you have any questions before we begin?"

Control condition. The total duration of the study for the control group was approximately 30 min. Tasks were also consistent across participants. They completed the demographics questionnaire, the self-rating of topic knowledge, the achievement test, and rating of overall motivation in this order. Learners completed the achievement test without searching the Internet, and thus served as a baseline measure of topic knowledge.

Coding of the Internet Navigations and Pupillary Information

Internet navigations. The total number of unique webpages accessed across all participants was 397. Each webpage was first coded as containing or not containing relevant information, resulting in approximately 32% of the webpages classified as relevant pages. Appendix I provides the complete list of the webpages accessed and their relevancy coding. GazeTracker (gaze-tracking software) recorded a video of the learners' navigation on the Internet and overlaid the pattern of their gaze. Within each video, lookzones to identify webpages and information were created. Lookzones are regions of interest which I defined for the software by outlining the object of interest using a rectangular shape within a particular frame of the video. Figure 2 presents an example frame from a video with lookzones imposed. Start and end times (to the nearest 50 ms) corresponding to the appearance and disappearance of the objects were found and attached to each lookzone. Lookzones had to be created around each webpage to identify the appearance and disappearance of each URL, including webpages and search engines, and around each paragraph containing relevant information. To account for scrolling, and thus movement of the paragraph within the video, I went through the sections of the video corresponding to studying relevant webpages frame by frame (or every 50 ms). I recorded the time that paragraphs shifted out of the created lookzone, and used the lookzone movement feature to shift the lookzone at the specified time to correspond with scrolling. Each video took approximately 3.5 hours to code for lookzones.

The output data for each video consisted of approximately 60,000 rows within SPSS. Each row was a snapshot of a participant's Internet navigation occurring approximately every 0.017 sec, and consisted of pupil diameter (X and Y axis) in pixels, time codes and lookzone labels. To ensure that the starting point within the video was the same across participants, the starting time for the 20 min study began from when the first webpage appeared following the Brock University homepage (www.brocku.ca), the starting point for each participant.

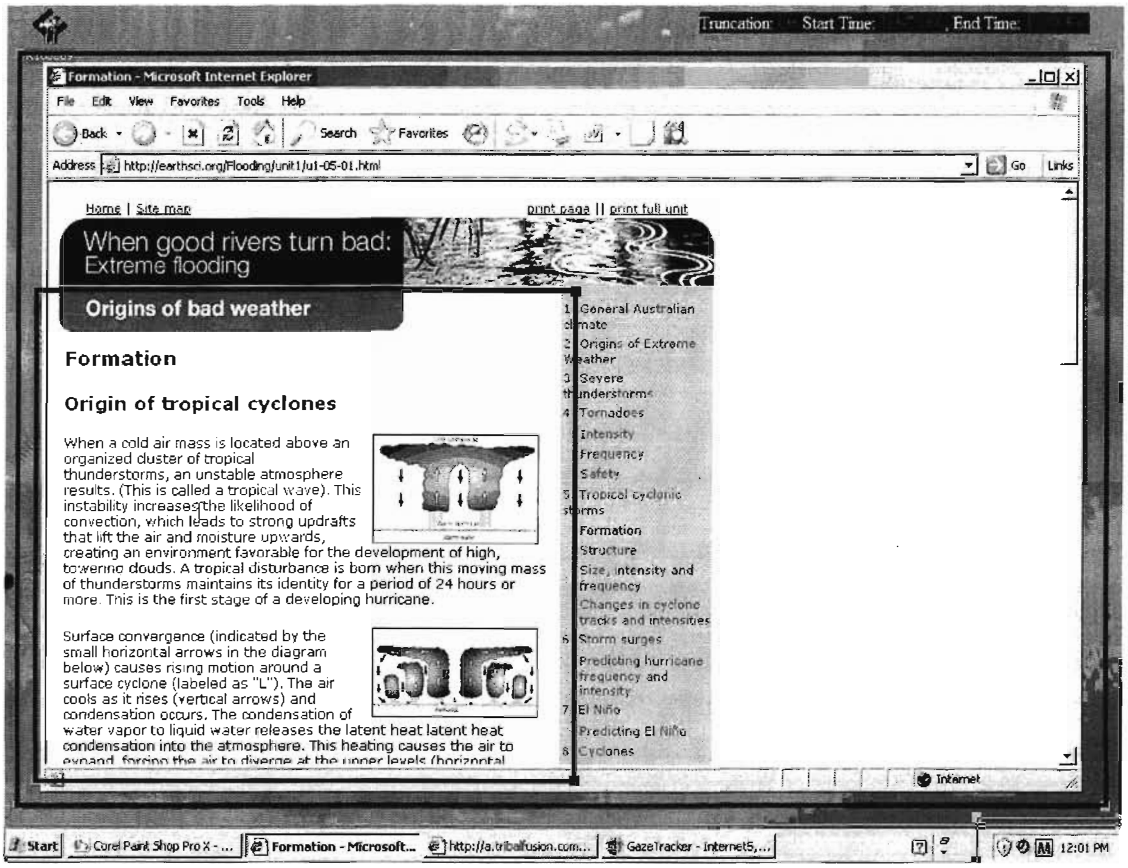

Figure 2. A sample image of creating lookzones in GazeTracker. This is a snapshot of the computer screen during coding. The large square surrounding the Internet window is the lookzone representing the webpage, and the smaller square around the text is the lookzone coding for the relevant information on the page. This lookzone is made larger when the participant scrolls down to include all relevant information observed on the screen.

To obtain inter-rater reliability for the coding of relevancy within webpages, two raters coded 22% of the 397 webpages accessed. Raters coded each paragraph within each of these webpages as either containing or not containing relevant information. This resulted in the coding of 563 paragraphs, and raters agreed on the relevancy coding for all but eight paragraphs. Thus, inter-rater agreement was 98.58%. A single rater coded the remaining webpages.

Navigation behaviours that were coded included the following: (a) proportion of webpages accessed that were classified as containing relevant information (hereon referred to as proportion of relevant pages), (b) proportion of time spent studying information found in relevant paragraphs (hereon referred to as time spent with relevant information), (c) proportion of time spent revisiting passages that contained relevant information (hereon referred to as revisiting), (d) greatest number of windows opened at any one time, (e) total number of search engines used, (f) total number of unique search terms that were specific to the topic, and (g) total number of unique search terms that addressed the general topic area. Table 2 provides a summary of these behaviours, the means, as well as measures of variability and normality.

Relevant information. In terms of relevancy, navigations were coded for two main types of behaviours. First, the proportion of relevant pages was calculated by counting the number of webpages accessed that were classified as relevant divided by the total number of webpages accessed. Second, and most importantly, time spent with relevant information was calculated based on eye gaze. Each lookzone that represented relevant information was divided into two scores: (a) the duration spent within the

Table 2

Descriptive Information for Navigation Behaviours

Navigation Behaviour	Coding	Observed Range	M (SD)	Skewness	Kurtosis
Time spent with relevant info on initial visits	Total time studying relevant information during initial visit divided by the total time studying information	0.002 to 0.75	0.37 [b] (0.17)	-0.06	-0.39
Revisiting	Total time studying relevant information on a webpage that learners returned to at a later point in their session	0.00 to 0.54	0.07[b] (0.13)	2.11 (1.92)[a]	3.87 (2.87)[a]
Time spent with relevant info (total)	Total time studying relevant information divided by the total time studying information	0.05 to 0.92	0.44 (0.17)	-0.01	-0.06
Proportion of relevant pages	Total number of webpages that contained relevant information divided by the total number of webpages accessed	0.06 to 1.00	0.57 (0.23)	0.01	-0.63
Number of relevant pages	Total number of webpages that contained relevant information accessed	1 to 15	5.95 (2.88)	0.40	0.17
Number of irrelevant pages	Total number of webpages that did not contain any relevant information accessed	0 to 27	5.86 (5.20)	1.53	2.92
Number of relevant pages > 60 sec	Total number of webpages that contained relevant information accessed which were viewed for longer than 60 sec	1 to 7	3.93 (1.59)	-0.10	-0.55
Number of irrelevant pages > 60 sec	Total number of webpages that did not contain any relevant information accessed which were viewed for longer than 60 sec	0 to 7	0.86 (1.24)	2.25 (0.79)[a]	7.21 (-0.31)[a]

(continued)

Navigation Behaviour	Coding	Observed Range	*M* (*SD*)	Skewness	Kurtosis
Max. # of windows opened	Highest number of windows opened at any point in time	1 to 6	1.51 (1.09)	2.35 (1.88) [a]	5.05 (2.36) [a]
# Search engines	Total number of different search engines accessed	0 to 4	1.28 (0.61)	2.03 (0.26) [a]	5.04 (2.92) [a]
# Specific terms	Total number of unique search terms that were specific to the topic (e.g., how tropical cyclones form)	0 to 3	1.02 (0.51)	1.14	5.27
# General terms	Total number of unique search terms that targeted the topic in a general manner (e.g., tropical cyclones)	0 to 2	0.55 (0.57)	0.39	-0.81

[a]Values after applying the log10 transformation. [b]Due to the floor effect observed for this navigation behaviour, the frequency was collapsed with time spent with relevant information during initial visits to form a total proportion of time spent with relevant information.

lookzone during the initial visit to a particular webpage, and (b) the duration spent within the same lookzone during subsequent visits. For a visit to a lookzone to be considered revisiting, participants were required to change URLs between visits to relevant paragraphs. For example, paragraph one of *Wikipedia: tropical cyclones* webpage was classified as containing relevant information. If a learner viewed paragraph one, scrolled to another section within the same webpage and then later returned to paragraph one within the same visit, then the appearances of lookzone one would contribute to the score of initial duration. However, if the participant left *Wikipedia: tropical cyclones* and returned to the webpage after visiting another URL (i.e., webpage or search engine), then the time spent with paragraph one during that subsequent visit would contribute to the duration of time spent revisiting.

Therefore, to calculate the proportion of time spent with relevant information on initial visits, the duration spent within all lookzones coded for paragraphs containing relevant information on initial visits were summed across the entire 20 min session. This total was divided by the total amount of time spent viewing webpages (excluding search engines) to provide a proportion of study time spent with relevant information on initial visits. Similarly, to score proportion of time spent revisiting relevant information, the duration spent within all lookzones coded for paragraphs containing relevant information during revisits were summed across the entire 20 min session. This total was divided by the total amount of time spent viewing webpages (excluding search engines) to provide a proportion of study time spent revisiting relevant information. These proportions were summed together to obtain a total proportion of time spent with relevant information.

Maximum number of windows opened. The number of windows opened represented the greatest number of windows opened simultaneously, including windows intentionally opened by the participant and those opened automatically by clicking on links within webpages. This enabled participants to keep webpages opened in one window while visiting other webpages in additional windows.

Search behaviours. To assess searches, the number of search engines (e.g., google, google images, and yahoo) was tallied for each participant. Figure 3 provides a list of all search engines accessed as well as the percentage of participants who used each search engine. In addition, the following frequencies were created for the following categories of search terms: (a) the unique search terms that addressed the topic specifically (e.g., how tropical cyclones form, or tropical cyclone formation), and (b) the unique search terms that focused on the general topic area (e.g., tropical cyclones). Some participants, for example, used the term combination "tropical cyclone formation" and then changed the combination to "formation of tropical cyclone" or "tropical cyclone forms". In either case, participants received a score of 1 unique specific term. However, if participants used the first combination but then changed to "hurricane formation" or "how do cyclones start" then participants would receive a tally of 2 for specific search terms. Appendix J provides a list of all search terms used separated by category as well as the percentage of participants who used each search term.

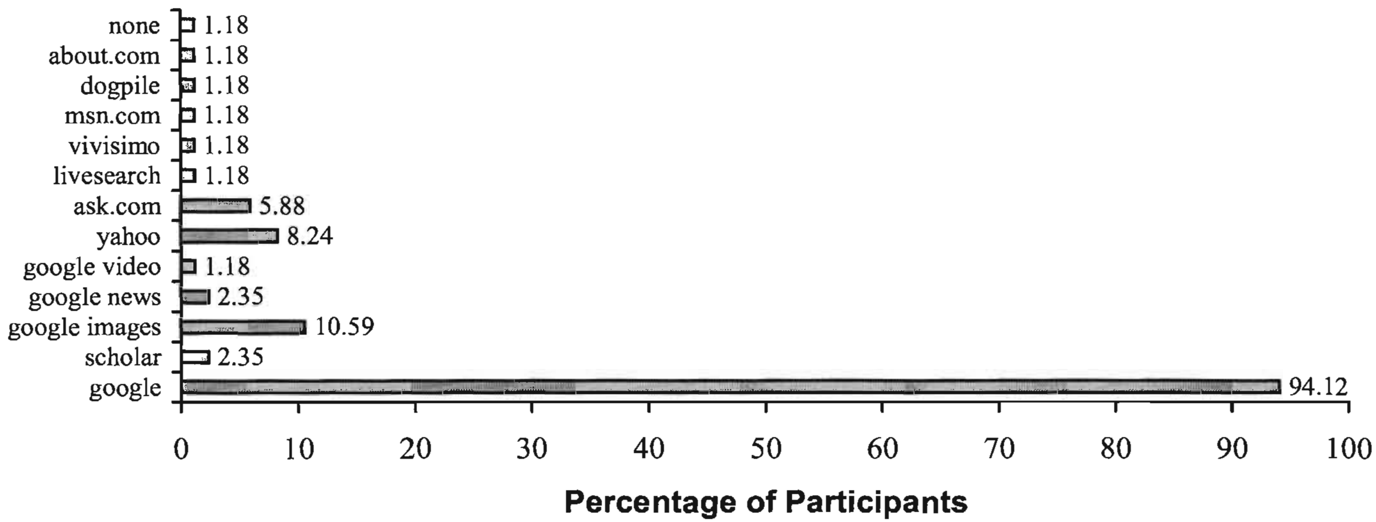

Figure 3. A list of the search engines used along with the percentage of participants who used each search engine.

Pupillary information. Momentary changes in pupil size within a task have been measured by taking the difference between the pupillary response at one component of a task and the pupillary response at a subsequent component of the same task. For example, Graholm et al. (1996) explored momentary changes in mental effort during a digit span task by calculating the difference between the average pupil diameter while reading a list of digits (i.e., first component) and the average pupil diameter when subsequently recalling that list of digits (i.e., subsequent component). Graholm et al. then compared the magnitude of change between learning and recall for the various digit span lengths (see also Hyona et al., 1995). This technique for assessing changes in mental effort was adapted for the current study to assess changes in mental effort within a task with a single component. Since the Internet session consisted only of a learning component, the 20 minute session was divided into 20 epochs - each 1 minute in length - and the change in pupil size from epoch to epoch was calculated[7].

More specifically, a continuous recording of pupil diameter was obtained while learners navigated the Internet. Gazetracker provided pupil diameter (measured in pixels) approximately every 0.017 sec. The diameter measurements were standardized within participants to eliminate individual differences in baseline pupil size. In addition, to eliminate artifacts, errors in recording, and changes in pupil size associated with blinking, pupil diameters which exceeded three standard deviations above and below the mean were excluded from analyses. For each participant, the Internet study session was divided

[7] Since I was interested in the pupil changes for each participant within their Internet navigation I did not record a baseline measure of pupil diameter. Therefore, I cannot determine the average level of mental effort invested based on pupil diameter. However, a subjective measure of the overall level of mental effort was included and is reported in later analyses.

into 20 1 minute epochs and the mean pupil size (as a *Z*-score) was calculated for each epoch. The average pupil diameter within each minute was calculated because I was interested in measuring processing of information, which could not be captured in a single point in time. The differences in pupil diameter from one epoch to the next were calculated (e.g., from min 1 to min 2, min 2 to min 3, and so on until min 19 to min 20) for a total of 19 difference scores; positive values represented increases in pupil diameter (and thus mental effort) in relation to the previous epoch.

To explore the changes in mental effort over the entire 20 min, two indicators were calculated. First, the average change in pupil size (ACPS) was calculated by taking the average of the 19 difference scores. Positive values represented larger increases in pupil size on average or less stability in mental effort throughout the Internet session. However, because increases would probably be followed by decreases, and vice versa, the effects may likely be cancelled out when an average is calculated. In addition, within each session, it was expected that learners would access some webpages or passages that were more comprehensive and challenging than others and that some sections or webpages would have more irrelevant stimuli (pictures and text) than others. The ACPS may not capture the variation experienced by each learner, and thus a second value was calculated based only on the sudden increases in pupil size.

Researchers have indicated that relatively small changes in pupil diameter are considered meaningful (e.g., Ahern & Beatty, 1979) and that a half standard deviation represents meaningful change for such variables as health-related quality of life (Hays et al., 2009; Norman, Sloan, & Wyrwich, 2003). Therefore, increases in pupil diameter exceeding a half a standard deviation from one epoch to the next were regarded as meaningful, and the frequency of such increases was calculated. Since pupil dilation has been associated with increases in mental effort, a greater frequency of increases was considered to represent more instances of increased mental effort throughout the Internet session.

Results

First, preliminary analyses were conducted to examine similarities and differences between the Internet and control groups, in addition to the characteristics of the control and predictor variables' distributions. Second, analyses addressing each of the main hypotheses are discussed. Finally, additional analyses were run to explore learner-related factors as predictors of particular navigation behaviours. All analyses were conducted with an alpha level of 0.05, unless otherwise stated.

Preliminary Analyses

Zero-order correlations among all variables included in the current study are included in Appendix M.

Comparing characteristics of the Internet and control groups. Three independent *t*-tests were conducted to ensure that the Internet and control groups did not differ on self-reported ratings of prior knowledge for how tropical cyclones form, knowledge of the Internet, and overall motivation. Table 1 presents the means and standard deviations for these variables as a function of condition. There was no difference in prior knowledge for how tropical cyclones form, $t(104) = 0.58, p = 0.57$, or for Internet knowledge, $t(104) = 0.18, p = 0.86$. However, the Internet group did report significantly higher overall motivation in comparison to the control group, $t(104) = 5.84, p < .001$. Despite this, overall motivation was not related to achievement within the control group, $r(21) = 0.04, p = 0.88$, and was at the level of significance for the Internet group, $r(85) = 0.21, p = 0.05$.

The range of prior tropical cyclone knowledge self-ratings was 1 to 7 (with 5 or more typically considered as higher prior knowledge). Initially, participants who reported high prior knowledge were to be excluded from the study; however, there was no significant relation between prior knowledge ratings and overall achievement for the control group, $r(21) = 0.34$, $p = 0.14$. Given that a small sample size may account for the lack of significance (i.e., with $n = 21$, the correlation needed to exceed 0.42 to be significant), prior knowledge ratings were controlled for in all appropriate analyses. In addition, overall motivation and Internet knowledge were also entered as covariates.

Investigating normality and intercorrelations among the control variables. All of the main analyses included the following five variables as controls: self-assessment of knowledge for how tropical cyclones form (topic knowledge), self-assessment of Internet knowledge (Internet knowledge), self-reported overall motivation, reading comprehension, and general mental ability. Table 1 presents the means, standard deviations, internal consistency indicators, and information regarding distributions of the control variables. The values corresponding to skewness and kurtosis were within the acceptable ±2.0 range, indicating that all control variables were normally distributed (Hutcheson, Graeme, & Sofroniou, 1999). The data was checked for outliers, and all participants scored within three standard deviations of the mean on all variables. In addition, Table 3 provides the correlations among the control variables[8]. All correlations were below 0.60 indicating that the control variables were not redundant. Reading comprehension and general mental ability scores, which were the only significantly related variables, were positively correlated at a low/moderate level. Specifically, learners who showed higher reading comprehension scores also showed greater general mental ability.

[8] The correlations were consistent when including the entire Internet group ($n = 110$).

Table 3

Correlations between Control Variables for the Internet Group

	1	2	3	4
1. Reading comprehension				
2. General mental ability	0.28*			
3. Internet knowledge	0.14	0.19†		
4. Topic knowledge	-0.02	0.04	0.02	
5. Overall motivation	-0.08	-0.02	0.15	0.10

†$p < .10$. *$p < .05$.

Investigating normality and intercorrelations among the predictor variables. Predictor variables for the main analyses included navigation behaviours and learner characteristics. The navigation behaviours included the following: time spent with relevant information on initial visits, revisiting, proportion of relevant webpages, maximum number of windows opened, total number of search engines used, number of specific search terms, and number of general search terms. Table 2 provides information regarding the mean engagement, variability and normality of these behaviours. Given that participants rarely revisited relevant information, this behaviour was combined with the proportion of time spent with relevant information on initial visits to form an overall proportion of time spent with relevant information ($M = 0.44$, $SD = 0.17$). Skewness (-0.01) and kurtosis (-0.06) indicators for the time spent with relevant information in total were within the range for a normal distribution.

The maximum number of windows opened, and number of search engines used were slightly beyond an acceptable cutoff value of 2.0 for skewness (Hutcheson et al., 1999), indicating a deviation from normality in their distributions. A log10 transformation was performed to correct normality, which brought all three variables' indicators within the acceptable range. The transformed variables were used in the appropriate analyses. Independence among predictors for time spent with relevant information was also checked (see Table 4). All correlations were below 0.60, indicating that the navigation behaviours were not redundant. In addition, all navigation behaviours were checked for outliers. For the number of windows opened and number of search engines used, one participant scored more than 3 *SD*s above the mean (3.37 and 3.51, respectively). However, given the limited variability within these behaviours, the presence of an outlier was not surprising. Analyses were rerun excluding the outlier on each variable, and the results remained the same. Therefore, the results reported did not exclude the outliers in order to maintain higher degrees of freedom.

Table 4

Correlations between Navigation Behaviours for the Internet Group

	1	2	3	4
1. proportion of relevant pages				
2. maximum # of windows opened[a]	-0.16			
3. # search engines[a]	-0.19	0.06		
4. # specific terms	0.07	0.17	0.28**	
5. # general terms	-0.44**	0.17	-0.19	-0.00

[a]Variables underwent a log10 transformation.
* $p < .05$. ** $p < .01$.

The learner characteristics explored included general intrinsic motivation and general effort regulation (both subscales of the MSLQ), in addition to cognitive style, WM control, and distractibility. Table 5 provides the correlations among all learner-related factors. Given that none of the correlations were greater than 0.60, these variables were not considered redundant. The correlations indicated that a greater tendency to control effort and attention when faced with challenging or uninteresting tasks (i.e., general effort regulation) was associated with lower distractibility. In addition, learners who adopted an intrinsic goal orientation to a greater extent when completing school-based tasks also reported greater effort regulation and lower levels of distractibility. Table 6 presents the means, standard deviations, reliability coefficients, and information regarding the shape of the distributions for the learner characteristics.

Table 5

Correlations between Learner-related Factors for the Internet Group

	1	2	3	4
1. Intrinsic goal orientation				
2. Effort regulation	0.45**			
3. Distractibility	-0.35**	-0.30**		
4. Cognitive style[a]	-0.03	-0.12	0.10	
5. WM control	0.12	0.02	-0.06	-0.08

Note. WM = working memory.
[a] $n = 84$.
$^{*}p < .05$. $^{**}p < .01$.

Table 6

Descriptive Information for Learner Characteristics

Category Variable	Scale	Higher Scores Indicate	α	Range: Possible (Observed)	*M* (*SD*)	Skewness	Kurtosis
Self-regulated Learning Characteristics							
Intrinsic goal orientation	MSLQ	greater degree to which the learner is participating in a task to be challenged, for curiosity or mastery	0.72	1 to 7 (2 to 7)	4.62 (0.98)	-0.11	0.38
Effort regulation	MSLQ	greater ability to control effort and attention when faced with challenging or uninteresting tasks	0.78	1 to 7 (1.75 to 7)	4.23 (1.10)	-0.58	0.20
Cognitive Factors							
WM control	OSPAN task	higher working memory control	--	0 to 60 (0 to 28)	5.73 (4.23)	1.93	8.14
Distractibility	Attentional control scale	greater distractibility	0.80	0 to 3 (0.35 to 2.30)	1.47 (0.39)	-0.27	-0.04
Cognitive style	Group Embedded Figures Test	< 11.4 reflects field dependent cognitive style; > 11.4 reflects field independent cognitive style	--	0 to 18 (2 to 18)	12.42 (4.22)	-0.58	-0.73

All learner characteristics were checked for outliers. There was one score for WM control which corresponded to 5.26 *SDs* above the mean. Analyses including WM control were run with and without this participant's data. The results were identical and thus the following results represent the data from 85 participants.

Overview of Internet navigations. The total number of unique webpages accessed among all participants was 397 (see Appendix I for a complete list of the unique webpages along with their relevancy classification). However, the total number of webpages visited per participant, including both relevant and irrelevant pages, ranged from 1 to 33 ($M = 11.81$, $SD = 6.13$; see Table 2 for descriptive information). However, the range decreased considerably when excluding webpages learners accessed but left fairly quickly (i.e., duration was less than 60 sec). The average webpage accessed contained 1414 words, with a median of 484. According to Adam, Carpenter, and Woolley (1982), the mean processing time for a word among adults is 249 msec. Therefore, it would take learners approximately 5.65 min to process the average webpage (or 1.94 min for the median). Therefore, learners would not have processed much information, if at all, when viewing webpages for less than 60 sec. The total number of webpages per participant containing relevant information visited for longer than 60 sec ranged from 1 to 7 ($M = 3.93$, $SD = 1.59$), and webpages that did not contain any relevant information ranged from 0 to 7 ($M = 0.86$, $SD = 1.24$). Interestingly, 44 participants did not spend longer than 1 min on any irrelevant webpage they accessed (Figure 4 presents the number of webpages accessed exceeding 1 min for relevant and non-relevant pages and the associated percent of participants). Thus, the majority of participants were able to

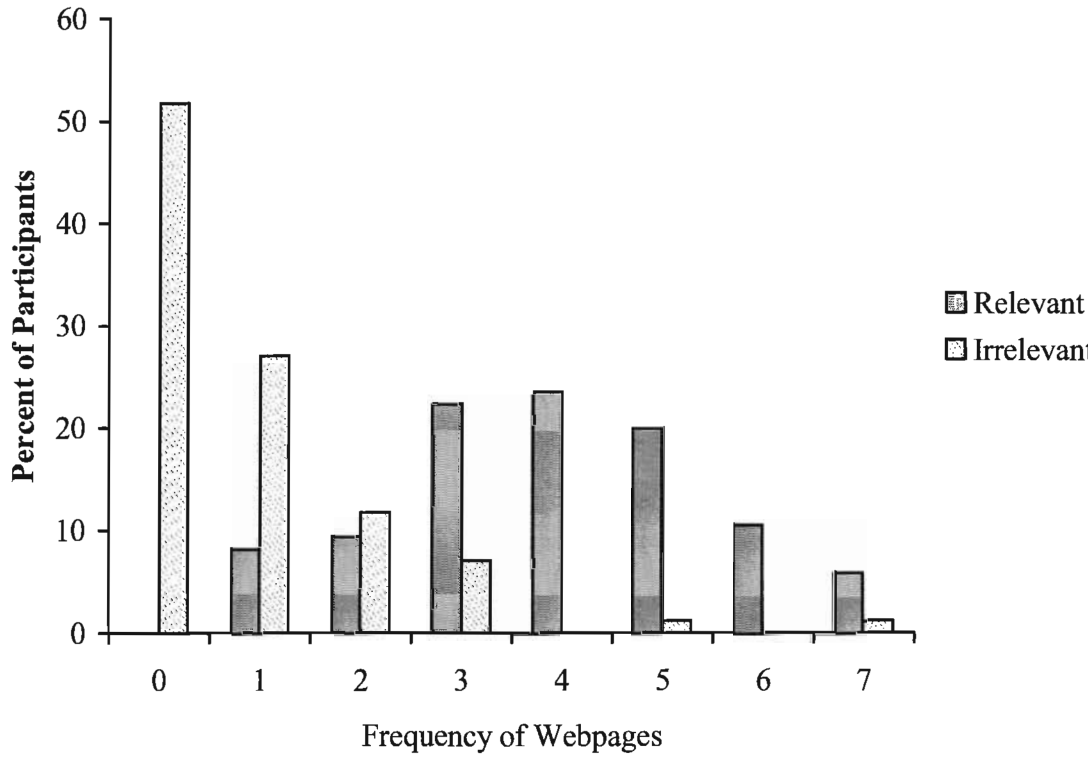

Figure 4. The frequency of webpages accessed which exceeded 60 sec as a function of relevancy and the associated percent of participants.

at least distinguish between webpages that contained relevant information versus webpages that were completely irrelevant. In addition, the Internet group indicated that they were able to find relevant information with very little difficulty ($M = 2.66$, $SD = 1.59$).

A comparison of achievement: Control versus Internet group. To assess whether novices learned from their exposure to the Internet for 20 min, achievement scores were compared between the Internet and control groups. Overall motivation, topic knowledge, and Internet knowledge were included as covariates. Since the control group did not complete the reading comprehension and general mental ability tasks, these measures could not be included as covariates in the current analysis. A univariate analysis was conducted with achievement scores as the dependent variable, condition as the independent variable, and overall motivation, topic knowledge, and Internet knowledge as covariates. Topic knowledge was a significant covariate, $F(1, 101) = 5.37$, $p = 0.02$. In contrast, Internet knowledge, $F(1, 101) = 0.01$, $p = 0.92$, and overall motivation, $F(1, 101) = 3.04$, $p = 0.08$, were not significant covariates. More importantly, however, the Internet group ($M = 41.43\%$, $SD = 11.63$) performed significantly higher on the achievement test in comparison to the control group ($M = 19.56\%$, $SD = 15.09$), $F(1, 101) = 33.17$, $p < 0.001$, $\eta_p^2 = 0.25$[9]. In fact, all learners in the control group scored below a typical passing grade of 50%, and 41% of the Internet group scored higher than the upper bound of the control group.

[9] The analysis was rerun with the entire sample ($n = 131$), and the results did not change. The mean achievement score pertaining to the entire Internet group ($M = 41.62$, $SD = 11.17$, $n = 110$) was very similar to the achievement score of the Internet group consisting of 85 participants.

Investigating learner-related factors and navigation behaviours as direct predictors of achievement. Previous research has identified effects of cognitive factors, self-regulated learner characteristics and navigation behaviours on achievement. Three hierarchical regression analyses were conducted to explore whether cognitive factors (see Table 7), self-regulated learning characteristics (see Table 8), and navigation behaviours (see Table 9) predicted achievement. With achievement as the criterion variable, the five control variables were entered in the first step, and the predictors were entered simultaneously on the second step of each regression. None of the predictors accounted for a significant proportion of variance in achievement.

Table 7

Regression Analysis Predicting Achievement from Cognitive Factors

Variable	Step 1	Step 2
	Parameter estimates (β)	
Reading comprehension	0.31**	0.31**
General mental ability	0.01	0.00
Internet knowledge	-0.10	-0.10
Topic knowledge	0.20†	0.24*
Overall motivation	0.27*	0.23
Cognitive style		0.07
WM control		-0.12
Distractibility		-0.03
	Model fit	
R^2	0.19	0.21
ΔR^2	0.19**	0.02

Note. $n = 84$; WM = working memory.
† $p < 0.10$. $*p < 0.05$. $**p < 0.01$.

Table 8

Regression Analysis Predicting Achievement from Self-regulated Learning Characteristics

Variable	Step 1	Step 2
	Parameter estimates (β)	
Reading comprehension	0.26*	0.25*
General mental ability	0.09	0.12
Internet knowledge	-0.08	-0.12
Topic knowledge	0.18†	0.20
Overall motivation	0.23*	0.28*
Intrinsic motivation		-0.04
Effort regulation		-0.15
	Model fit	
R^2	0.16	0.18
ΔR^2	0.16*	0.02

† $p < 0.10$. * $p < 0.05$.

Table 9

Regression Analysis Predicting Achievement from Navigation Behaviours

Variable	Step 1	Step 2
	Parameter estimates (β)	
Reading comprehension	0.26*	0.28*
General mental ability	0.09	0.11
Internet knowledge	-0.08	-0.09
Topic knowledge	0.18	0.23*
Overall motivation	0.23*	0.23*
Proportion of relevant pages		0.18
Max. # windows opened[a]		0.06
# Search engines[a]		-0.01
# Specific terms		-0.12
# General terms		0.08
	Model fit	
R^2	0.16*	0.23
ΔR^2	0.16*	0.07

[a]. Variables included in analysis underwent a log10 transformation.
* $p < 0.05$.

Evaluating changes in pupil diameter as an indicator of mental effort.

Previous research has identified that increases in pupil size are associated with increases in invested mental effort (e.g., Granholm et al., 1997; Paas et al., 2003). To investigate this pattern within the current study, changes in pupil diameter during the WM control task (i.e., OSPAN task) were analyzed. During the OSPAN task learners were required to identify the accuracy of mathematical operations while simultaneously remembering words. Learners were presented with 2, 3, 4, 5 or 6 operation-word pairs before recalling the words (i.e., 5 block sizes). The mean pupil diameter (measured in pixels) was calculated for each block, resulting in five mean pupil sizes. Due to equipment difficulties (n = 5) or learners closing their eyes when recalling the words (n = 2), a total of 78 of the 85 participants were included in the following analyses.

A one-way repeated measures analysis of variance (ANOVA) was conducted, with block size as the within variable, and mean pupil size when trying to recall the words for each block as the dependent variable. The pupil size pertaining to when learners recalled the words was analyzed because recall occurred immediately following the last presentation of the operation-word pair. This would capture the maximum point of invested mental effort for the block. The assumption of sphericity was violated, and thus the Greenhouse-Geisser correction was used. There was a main effect of block size, $F(4, 308) = 24.81, p < .001, \eta_p^2 = 0.24$. Four paired sample t-tests were conducted to compare pupil diameter (n vs. $n + 1$). A Bonferroni correction was used to control for the number of planned comparisons (0.05/4 = 0.013). Table 10 provides descriptive information pertaining to the pupil size as a function of block size. Pupil size corresponding to when learners tried to recall two words was less than when required to recall three words; however, this did not reach significance, $t(77) = 2.17, p = 0.03$. Similarly, pupil size corresponding to when learners were to recall three words was not significantly different than pupil size when learners tried to recall four words, $t(77) = 0.73, p = 0.47$. In contrast, pupil size corresponding to when learners were to recall four words was significantly less than when trying to recall five words, $t(77) = 3.51, p = 0.001$, which in turn was less, although not significant, than when required to recall six words, $t(77) = 2.37, p = 0.02$[10]. Overall, the mean pupil size seemed to increase with block size.

Table 10

Descriptive Statistics for Pupil Size as a Function of Block Size in the OSPAN task

Number of words to-be-recalled in each block	*M*	*SD*	*SE*
2 words	57.13	8.84	1.00
3 words	57.55	8.74	0.99
4 words	57.88	9.77	1.11
5 words	59.34	9.07	1.03
6 words	59.84	9.35	1.06

Note. $n = 78$.

Main Analyses

Q1) Does time spent with relevant information predict achievement?

Although the Internet group as a whole benefitted from studying the Internet, there was great variability in their achievement scores ($SD = 11.63$, Range = 14.29% to 75.00%). It was hypothesized that some novices may have had difficulty distinguishing between goal-relevant and irrelevant information within a webpage, and thus may have spent less

[10] Analyses were rerun with data pertaining to 98 participants (the participants in the full sample with useable pupil data pertaining to the OSPAN task). Pupil size corresponding to when learners tried to recall two words was significantly less than when required to recall three words, $t(97) = 2.77, p = 0.01$. In contrast, pupil size corresponding to when learners were to recall three words was not significantly different than pupil size when learners tried to recall four words, $t(97) = 1.12, p = 0.238$. However, pupil size corresponding to when learners were to recall four words was significantly less than when trying to recall five words, $t(97) = 3.96, p < 0.001$, which in turn was significantly less than when required to recall six words, $t(97) = 2.87, p = 0.01$.

time with relevant content. Overall, the proportion of time spent with relevant information on initial visits was 0.37 (*SD* = 0.17) and on revisitations was 0.07 (*SD* = 0.13). Given that participants rarely revisited relevant information, these Internet behaviours were collapsed into time spent with relevant information (*M* = 0.44, *SD* = 0.17) for all analyses.

A hierarchical regression was conducted with achievement scores as the criterion variable. The covariates were entered on step 1, and the time spent with relevant information was entered on the following step. Table 11 provides the results from the regression. Both steps were significant; however, step two was of particular interest. The time spent with relevant information ($\beta = 0.40, p < .001$) was a significant predictor of achievement over and above the control variables, accounting for an additional 15% of the total variance. Thus, in support of the hypothesis, a greater proportion of time spent with relevant information was related to higher achievement.

Q2) Does time with relevant information mediate the relation between increases in mental effort and achievement? To obtain a general understanding of changes in mental effort and its associations, I explored the relation of the average change in pupil size (ACPS) and subjective mental effort with both achievement and time spent with relevant information. ACPS was regarded as a measure of the *stability* in mental effort (with higher scores indicating greater fluctuation in mental effort), whereas subjective mental effort was considered a measure of average *level* of mental effort while learning from the Internet. Fluctuations in effort may be more important at particular levels of overall mental effort. Higher levels of mental effort may facilitate learning to a greater extent when learners show more changes in their effort in comparison to their

Table 11

Regression Analysis Predicting Achievement from Proportion of Time with Relevant Information

Variable	Step 1	Step 2
	Parameter estimates (β)	
Reading comprehension	0.26*	0.29**
General mental ability	0.09	0.05
Internet knowledge	-0.08	-0.05
Topic knowledge	$0.18^{\dagger}$	0.24*
Overall motivation	0.23*	0.25*
Time with relevant information		0.40***
	Model fit	
R^2	0.16	0.31
ΔR^2	0.16*	0.15***

$^{\dagger}p < 0.10$. $^{*}p < 0.05$. $^{**}p < 0.01$. $^{***}p < 0.001$.

peers who maintain a consistent or stable high mental effort. Fluctuation in effort when mental effort is at a relatively high level overall may prevent learners from feeling overwhelmed. Therefore, the main effects of and interaction between ACPS and subjective mental effort were explored as predictors of time spent with relevant information and achievement.

The distribution for the ACPS scores was leptokurtic, and therefore each value was squared to correct for the deviation from normality. Since the minimum value for ACPS was -0.35, 0.35 was added to each score to differentiate between negative and positive scores. Table 12 presents the descriptive statistics for the stability and subjective indictors of mental effort. Two hierarchical regression analyses were run with time spent with relevant information (see Table 13) and achievement (see Table 14) as the criterion variables. The 5 covariates were entered in step one and the main effects of ACPS and subjective overall mental effort were entered in step two. Next, the interaction between ACPS and subjective overall mental was entered in the final step. ACPS and subjective overall mental effort were standardized and the multiplication of the scores was computed based on the standardized scores.

Table 12

Descriptive Information for the Subjective and Objective Indicators of Mental Effort

Variable	Mean	SD	Skewness	Kurtosis
Subjective mental effort[a]	5.03	1.88	0.08	-0.73
Difficulty rating[a]	3.26	1.77	0.86	0.29
ACPS	-0.01 (0.58)[b]	0.06 (0.05)[b]	-1.45 (-0.23)[b]	10.23 (3.35)[b]
Sudden increases in mental effort	2.25	1.43	0.13	-0.62

Note. ACPS = average change in pupil size.
[a]n = 82. [b]Descriptives for ACPS after square transformation.

Table 13

Regression Analysis Predicting Achievement from Subjective Overall Level and Objective Stability of Mental Effort

Variable	Step 1	Step 2	Step 3
	Parameter estimates (β)		
Reading comprehension	0.26*	0.26*	0.26*
General mental ability	0.09	0.06	0.05
Internet knowledge	-0.07	-0.06	-0.06
Topic knowledge	0.18†	0.14	0.14
Overall motivation	0.22*	0.22*	0.22*
ACPS		0.27*	0.25*
Subjective level of mental effort		-0.06	-0.06
ACPS X Subjective mental effort			0.05
	Model fit		
R^2	0.16	0.24	0.24
ΔR^2	0.16	0.08*	0.00

Note. ACPS = average change in pupil size measured in standard deviations (and underwent a squared transformation).
$^*p < 0.05$. $^{\dagger}p < 0.09$.

Table 14

Regression Analysis Predicting Time Spent with Relevant Information from Subjective Overall Level and Objective Stability of Mental Effort

Variable	Step 1	Step 2	Step 3
	Parameter estimates (β)		
Reading comprehension	-0.09	-0.10	-0.10
General mental ability	0.12	0.14	0.14
Internet knowledge	-0.07	-0.09	-0.09
Topic knowledge	-0.15	-0.14	-0.14
Overall motivation	-0.06	-0.04	-0.04
ACPS		-0.00	-0.01
Subjective level of mental effort		-0.15	-0.16
ACPS X Subjective mental effort			0.01
	Model fit		
R^2	0.05	0.07	0.07
ΔR^2	0.05	0.02	0.00

Note. ACPS = average change in pupil size measured in standard deviations (and underwent a squared transformation).
$^{\dagger}p < 0.09$. $^{*}p < 0.05$.

The subjective rating of participants' overall level of mental effort was not a significant predictor of either achievement or time spent with relevant information. However, subjective level of overall mental effort was significantly related to perceived difficulty, $r(83) = 0.42$, p < 0.001, indicating that learners who perceived the task as more difficult were also more likely to report having invested a higher level of mental effort overall. ACPS did significantly predict achievement ($\beta = 0.27$, $t(76) = 2.55$, $p = 0.01$), but not time spent with relevant information. Learners who exhibited greater fluctuation in their mental effort when learning from the Internet scored higher on the achievement test than learners who showed less fluctuation (or more stability) in mental effort. There was no interaction between stability and level of mental effort for either achievement or time spent with relevant information.

The primary interest of the current study, however, was to examine whether time with relevant information mediated the relation between changes in mental effort and achievement. When calculating the average change in pupil size (ACPS), increases may be cancelled out by decreases. Therefore, to gain a deeper understanding of the associations with increases in mental effort within a learning session, only the increases in pupil size were considered. More specifically, I was interested in the relation between time spent with relevant information, achievement, and frequency of sudden increases in mental effort regardless of the level of mental effort (operationalized as the frequency of increases exceeding 0.5 standard deviations). Table 12 provides descriptive information for frequency of sudden increases in mental effort.

To investigate time spent with relevant information as a mediator in the relation between sudden increases in effort and achievement, Baron and Kenny's (1986) four steps were used. First, to establish that there was an effect to be mediated, the first step tested that the predictor variable (sudden increases in effort) was related to the outcome variable (achievement). This step examined the direct effect of sudden increases in effort on achievement. The second step tested that the predictor variable (sudden increases in effort) was related to the mediator (time spent with relevant information). The third and fourth steps tested that the mediator (time spent with relevant information) was related to the outcome (achievement) after controlling for the predictor variable (sudden increases in effort), and that the relation between the predictor variable (sudden increases in effort) and outcome variable (achievement) was reduced after controlling for variability in the predictor and outcome variables due to the mediator.

Mediation analyses were conducted using the macro for SPSS provided by Preacher and Hayes (2008), which generated estimates for the direct and indirect effects in a mediator model including covariates[11]. The results of the four Baron and Kenney (1986) steps outlined above, using unstandardized beta coefficients, were as follows. First, the effect of the frequency of increases in effort on achievement was equal to 1.96 ($\beta = 0.24$, $t(78) = 2.35$, $p = 0.02$), indicating that the requirement for step 1 was met. Second, the effect of the frequency of increases in effort on time spent with relevant information was equal to 0.03 ($\beta = 0.27$, $t(78) = 2.45$, $p = 0.02$), and thus step 2 was also met. Third, the effect of time spent with relevant information on achievement after controlling for the frequency of increases in effort was equal to 24.93 ($\beta = 0.36$, $t(77) = 3.59$, $p < 0.001$), demonstrating that the requirement for step 3 was met. Finally, the effect of the frequency of increases in effort on achievement after controlling for time spent with relevant information was equal to 1.19 ($\beta = 0.15$, $t(77) = 1.48$, $p = 0.14$). Since there was a reduction in the relation between the predictor and outcome variables after controlling for the mediator, the requirements for step 4 were met. Figure 5 presents a summary of the results for the mediation model.

[11] The macro was obtained from: http://www.comm.ohio-state.edu/ahayes/SPSS%20programs/indirect.htm, which corresponds to Preacher and Hayes (2008) paper.

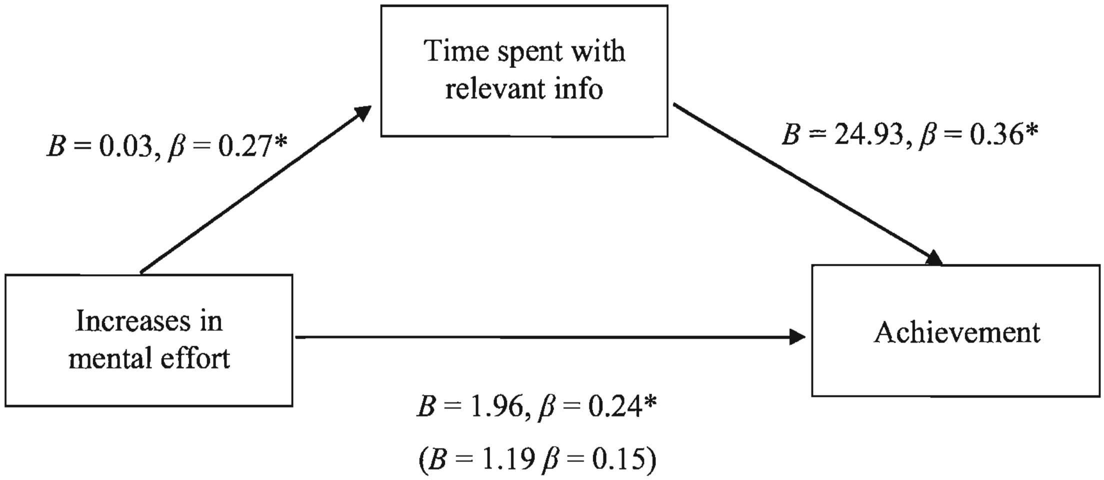

Figure 5. Summary of the mediation model. Unstandardized (B) and standardized (β) regression coefficients are presented for the relation between the frequency of increases in mental effort and achievement as mediated by time spent with relevant information. The standardized and unstandardized regression coefficients between increases in mental effort and achievement after controlling for time spent with relevant information are presented in parentheses. Regression coefficients shown with an asterisk are significant at the 0.05 level.

The indirect effect of sudden increases in effort on achievement was calculated by multiplying the unstandardized coefficients corresponding to path a (relation between sudden increases in effort and time spent with relevant information) and path b (relation between time spent with relevant information and achievement after controlling for sudden increases in effort). Thus, the indirect effect was equal to 0.75. The direct effect is represented by the unstandardized coefficient for the relation between sudden increases in effort and achievement, and was equal to 1.96. The percentage of the total effect that was mediated equaled 38.27%.

To test the significance of the mediation model, the Sobel test and bootstrapping techniques were used. First, the Sobel test involves computing the ratio of *ab* (product of unstandardized coefficients for path a and path b) to its estimated standard error (Z = ab/SQRT($b^2 * s_a^2 + a^2 * s_b^2$); Preacher & Hayes, 2008). Thus, the Sobel standard error was equal to 0.147, which makes the Z test of the indirect effect equal to 2.018 ($p = 0.04$). Because the Sobel test was statistically significant, it was concluded that the indirect effect of sudden increases in effort on achievement was significantly different from zero. Second, the bootstrapping technique was run to confirm the results of the Sobel test. Preacher and Hayes (2008) clearly summarized the method of this technique:

> Bootstrapping is a computationally intensive method that involves repeatedly sampling from the data set and estimating the indirect effect in each resampled data set. By repeating this process thousands of times, an empirical approximation of the sampling distribution of *ab* is built and used to construct confidence intervals for the indirect effect. (p. 880).

The bootstrap estimated indirect effect was 0.7720 with a standard error of 0.35. The 95% bootstrap confidence interval (5000 trials) was from 0.21 to 1.69. Since this interval did not include zero, it can be concluded that the indirect effect is significantly different from zero (Preacher & Hayes, 2008), which is consistent with the results of the Sobel test. Therefore, time with relevant information partially mediated the relation between sudden increases in effort and achievement.

Q3) Do navigation behaviours account for variability in time spent with relevant information? To explore why some novices spent more time with relevant information than others, the method in which learners navigated the Internet was considered including proportion of relevant webpages accessed, maximum number of windows opened simultaneously, number of search engines used, and number of general and specific search terms (see Table 2 for a description of navigation behaviours). It was expected that navigation behaviours would influence time spent with relevant information. Although directional predictions were not formulated for most of the navigation behaviours, it was expected that a greater number of windows opened would be positively related to time spent with relevant information. A hierarchical regression was conducted with time spent with relevant information as the criterion variable. The covariates were entered into step 1 and the navigation behaviours were entered simultaneously in the following step. Table 15 presents the results from the analysis. The entire model accounted for approximately 47% of the variance in the proportion of time spent with relevant information. The addition of the navigation behaviours accounted for an additional 42.5% of the variance over and above the control variables, with proportion of relevant pages as the only significant predictor ($\beta = 0.68$, $p < 0.001$). A greater proportion of webpages that contained relevant information was associated with more time spent attending to relevant information. There was a lack of variability in search behaviours including the number of search engines used, as well as the number of specific and general search terms used, which may account for the corresponding non-significant results. The majority of participants used only one search engine, opened only one window, conducted one specific search, and conducted either no or one general search. Figure 6 presents the frequencies of each of these navigation behaviours.

Table 15

Regression Analysis Predicting Proportion of Time with Relevant Information from Navigation Behaviours

Variable	Step 1	Step 2
	Parameter estimates (β)	
Reading comprehension	-0.08	-0.02
General mental ability	0.12	$0.16^{\dagger}$
Internet knowledge	-0.06	-0.03
Topic knowledge	-0.14	-0.01
Overall motivation	-0.07	-0.04
Proportion of relevant pages		0.68**
Max. # windows opened [a]		0.02
# Search engines [a]		-0.01
# Specific terms		0.16
# General terms		0.09
	Model fit	
R^2	0.04	0.47
ΔR^2	0.04	0.43***

[a]Variables included in analysis underwent a log10 transformation.
$^{\dagger}p < 0.10$. * $p < 0.05$. ** $p < 0.01$. *** $p < 0.001$.

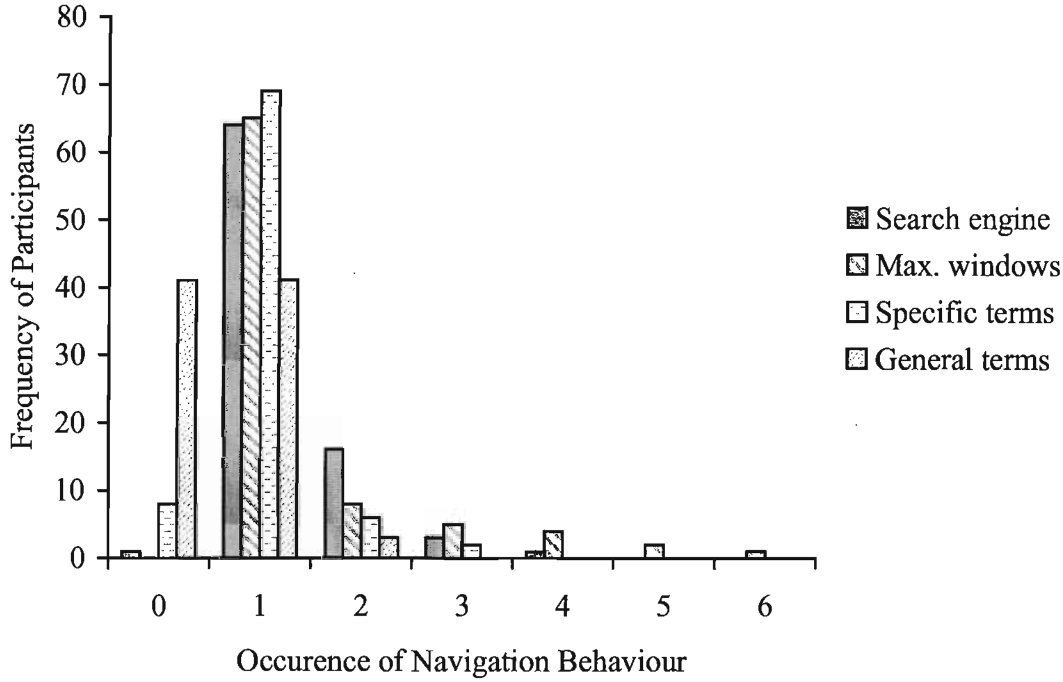

Figure 6. The frequency of participants who engaged in each of the navigation behaviours 0 to 6 times. The occurrence of navigation behaviours represents the number of times a participant used that technique during their 20 min with the Internet.

To determine whether the number of relevant or irrelevant webpages accessed was the stronger predictor, another hierarchical regression was conducted with time spent with relevant information as the criterion variable (see Table 2 for descriptive information pertaining to the predictors). The covariates were entered on the first step, and the numbers of relevant and irrelevant webpages accessed were entered on the second step. (The correlation between the number of irrelevant and relevant webpages accessed was not significant, $r(85) = 0.08, p = 0.50$). Greater time spent with relevant information was significantly related to a lower number of irrelevant webpages accessed, $\beta = -0.49, p < 0.001$, and a greater number of relevant webpages accessed, $\beta = 0.33, p = 0.001$ (see Table 16). Therefore, the number of irrelevant webpages accessed was a stronger predictor of time spent with relevant information when learning from the Internet than the number of relevant webpages accessed. Although, the general pattern of results did not change when including only webpages learners attended to for greater than 60 sec as the predictors, the number of relevant webpages accessed was not significant at the 0.05 level (see Table 17 for results of regression; see Table 2 for descriptive information pertaining to the predictors).

Q4a) Do self-regulated learning characteristics account for variability in time spent with relevant information? To investigate why some novices spent more time with relevant information than others, the following self-regulated learning characteristics were explored: general intrinsic goal orientation and general effort regulation. A summary of the self-regulated learning characteristics along with a description of how the behaviours were coded and descriptive information are presented in Table 3. A hierarchical regression was conducted with time spent with relevant information as the

Table 16

Regression Analysis Predicting Proportion of Time with Relevant Information from Number of Webpages

Variable	Step 1	Step 2
	Parameter estimates (β)	
Reading comprehension	-0.08	0.00
General mental ability	0.12	0.10
Internet knowledge	-0.06	-0.10
Topic knowledge	-0.14	-0.07
Overall motivation	-0.07	-0.03
Number of relevant pages		0.33**
Number of irrelevant pages		-0.49***
	Model fit	
R^2	0.04	0.35
ΔR^2	0.04	0.31***

* $p < 0.05$. ** $p < 0.01$. *** $p < 0.001$.

Table 17

Regression Analysis Predicting Proportion of Time with Relevant Information from Number of Webpages Exceeding 60 Seconds

Variable	Step 1	Step 2
	Parameter estimates (β)	
Reading comprehension	-0.08	-0.02
General mental ability	0.12	0.11
Internet knowledge	-0.06	-0.08
Topic knowledge	-0.14	-0.02
Overall motivation	-0.07	-0.02
Number of relevant pages > 60 sec		0.18†
Number of irrelevant pages > 60 sec[a]		-0.48***
	Model fit	
R^2	0.04	0.34
ΔR^2	0.04	0.30***

[a]Variables included in analysis underwent a log10 transformation.
$^{\dagger}p < 0.10$. * $p < 0.05$. ** $p < 0.01$. *** $p < 0.001$.

criterion variable. The control variables were entered in the first step, and the self-regulated learning characteristics were entered simultaneously in the second step. The model accounted for approximately 12% of the variance in the time spent with relevant information. More importantly, the second step was significant, accounting for an additional 8.0% of the variance over and above the control variables. General intrinsic goal orientation was negatively related to time spent with relevant information (β = -0.28, p = 0.045), indicating that those who typically adopt an intrinsic goal orientation spent less of their study time with relevant content. Although intrinsic goal orientation was a significant predictor as expected, the direction of the effect was in the opposite direction to my prediction. In contrast to my hypothesis, effort regulation was not a significant predictor of time spent with relevant information (see Table 18 for the complete results).

Table 18

Regression Analysis Predicting Proportion of Time with Relevant Information from Self-regulated Learning Characteristics

Variable	Step 1	Step 2
	Parameter estimates (β)	
Reading comprehension	-0.08	-0.07
General mental ability	0.12	0.18
Internet knowledge	-0.06	-0.04
Topic knowledge	-0.14	-0.06
Overall motivation	-0.07	0.01
Intrinsic goal orientation		-0.28*
Effort regulation		-0.05
	Model fit	
R^2	0.04	0.12
ΔR^2	0.04	0.08*

* $p < 0.05$.

Q4b) Do self-regulated learning characteristics account for variability in the frequency of increases in mental effort? It was expected that general intrinsic goal orientation and general effort regulation would be positively related to the frequency of increases in mental effort. A hierarchical regression analysis was conducted with the frequency of sudden increases in mental effort as the criterion variable. The control variables were entered in the first step, and self-regulated learning characteristics were entered simultaneously in the second step. The final step was significant, and accounted for an additional 11% of the variance over and above the control variables (see Table 19). General effort regulation was the only significant predictor (β = -0.26, p = 0.048). Unexpectedly, learners who indicated they typically controlled their effort and attention when faced with challenging or uninteresting tasks had fewer increases in mental effort than their peers who scored lower on the effort regulation scale[12].

Table 19

Regression Analyses Predicting the Frequency of Increases in Mental Effort from Self-regulated Learning Characteristics

Variable	Step 1	Step 2
	Parameter estimates (β)	
Reading comprehension	0.09	0.08
General mental ability	-0.05	0.03
Internet knowledge	0.14	0.09
Topic knowledge	-0.07	0.00
Overall motivation	0.09	$0.21^{\dagger}$
Intrinsic goal orientation		-0.16
Effort regulation		-0.26*
	Model fit	
R^2	0.04	0.15
ΔR^2	0.04	0.11*

$^{\dagger}p < 0.07$. $*p < .0.05$.

[12] The pattern of results was consistent with the analysis run with 101 participants.

Q5a) Do cognitive factors account for variability in time spent with relevant information? In addition, cognitive factors (cognitive style, WM control, and distractibility) were explored as influences on time spent with relevant information (see Table 2 for a summary of these factors, in addition to a description of how the behaviours were coded and descriptive information). It was anticipated that higher scores of cognitive style (indicating field independence) would facilitate time spent with relevant information. Significant two-way interactions between distractibility and frequency of increases in mental effort as well as WM control and frequency of increases in mental effort were also explored. Using a hierarchical regression with time spent with relevant information as the criterion variable, the control variables were entered in the first step, the cognitive factors and mental effort were entered simultaneously in the second step, and the two-way interactions of interest were entered in the final step. Table 20 presents the results from the analysis. Step two was the only significant step; however, frequency of increases in mental effort was the only significant predictor (a predictor not of interest for this particular analysis). Contrary to expectations, the main effect of cognitive factors and the two-way interactions were not significant.

Q5b) Do cognitive factors account for variability in the frequency of increases in mental effort? Cognitive style, WM control, and distractibility were hypothesized to influence the frequency of increases in mental effort, such that field independence, lower WM control, and higher distractibility may be related to a greater frequency of increases in mental effort. To examine the predictions, a hierarchical regression analysis was run with the frequency of increases in effort as the criterion variable. The control variables were entered in the first step and the cognitive factors were entered simultaneously on the next step. Neither step of the regression was significant at the 0.05 significance level (see Table 21). However, there was a trend in the predicted direction that higher levels of distractibility were associated with a greater frequency of increases in mental effort ($\beta = 0.22$, $p = .066$).

Table 20

Regression Analysis Predicting Proportion of Time with Relevant Information from Cognitive Factors

Variable	Step 1	Step 2	Step 3
	Parameter estimates (β)		
Reading comprehension	-0.03	-0.02	-0.03
General mental ability	0.04	0.11	0.12
Internet knowledge	-0.08	-0.10	-0.10
Topic knowledge	-0.13	-0.18	-0.19
Overall motivation	-0.03	0.01	0.01
Cognitive style		-0.22	-0.22
WM control		0.08	0.06
Distractibility		0.08	0.05
Increases in mental effort		0.30*	0.31*
WM control X Mental effort			-0.02
Distractibility X Mental effort			-0.06
	Model fit		
R^2	0.03	0.16	0.16
ΔR^2	0.03	0.13*	0.00

Note. WM = working memory
$^*p < 0.05$.

Table 21

Regression Analyses Predicting the Frequency of Increases in Mental Effort from Cognitive Factors

Variable	Step 1	Step 2
	Parameter estimates (β)	
Reading comprehension	0.06	0.11
General mental ability	-0.00	0.02
Internet knowledge	0.15	0.19
Topic knowledge	-0.08	-0.06
Overall motivation	0.07	0.12
Cognitive style		-0.09
WM control		-0.13
Distractibility		0.22†
	Model fit	
R^2	0.04	0.10
ΔR^2	0.04	0.06

Note. n= 84. WM = working memory.
†$p < 0.07$.

A Posteriori Analysis

The main purpose of the current study was to account for variability in time spent with relevant information. The proportion of relevant webpages accessed which exceeded 60 sec was the only navigation behaviour measured that significantly predicted time spent with relevant information. Variation in the webpages accessed could be due to differences in cognitive factors and/or self-regulated learning characteristics. To test this hypothesis two separate regression analysis were run with the proportion of relevant webpages accessed which exceeded 60 sec as the criterion variable. The 5 covariates were entered on the first step and the learner-related factors were entered on the second step. Tables 22 and 23 present the results from the hierarchical regressions for the cognitive factors and self-regulated learning characteristics respectively. None of the learner-related factors were significant predictors.

Table 22

Regression Analyses Predicting Proportion of Relevant Webpages Accessed Exceeding 60 Seconds from Cognitive Factors

Variable	Step 1	Step 2
	Parameter estimates (β)	
Reading comprehension	-0.01	0.02
General mental ability	-0.12	-0.06
Internet knowledge	-0.02	0.01
Topic knowledge	-0.22*	-0.26*
Overall motivation	-0.03	0.03
Cognitive style		-0.17
WM control		-0.01
Distractibility		0.08
	Model fit	
R^2	0.07	0.09
ΔR^2	0.07	0.02

Note. n = 84. WM = working memory.
$^*p < 0.05$.

Table 23

Regression Analyses Predicting Proportion of Relevant Webpages Accessed Exceeding 60 Seconds from Self-regulated Learning Characteristics

Variable	Step 1	Step 2
	Parameter estimates (β)	
Reading comprehension	-0.08	-0.08
General mental ability	0.04	0.03
Internet knowledge	0.06	0.06
Topic knowledge	-0.24*	-0.20†
Overall motivation	-0.08	-0.06
Intrinsic motivation		-0.19
Effort regulation		0.10
	Model fit	
R^2	0.07	0.09
ΔR^2	0.07	0.02

†$p < 0.09$. *$p < 0.05$.

Summary of Main Findings

A summary model of the significant results is presented in Figure 7.

Does time spent with relevant information predict achievement? Consistent with my hypothesis, a greater proportion of time spent with relevant information was associated with higher achievement scores.

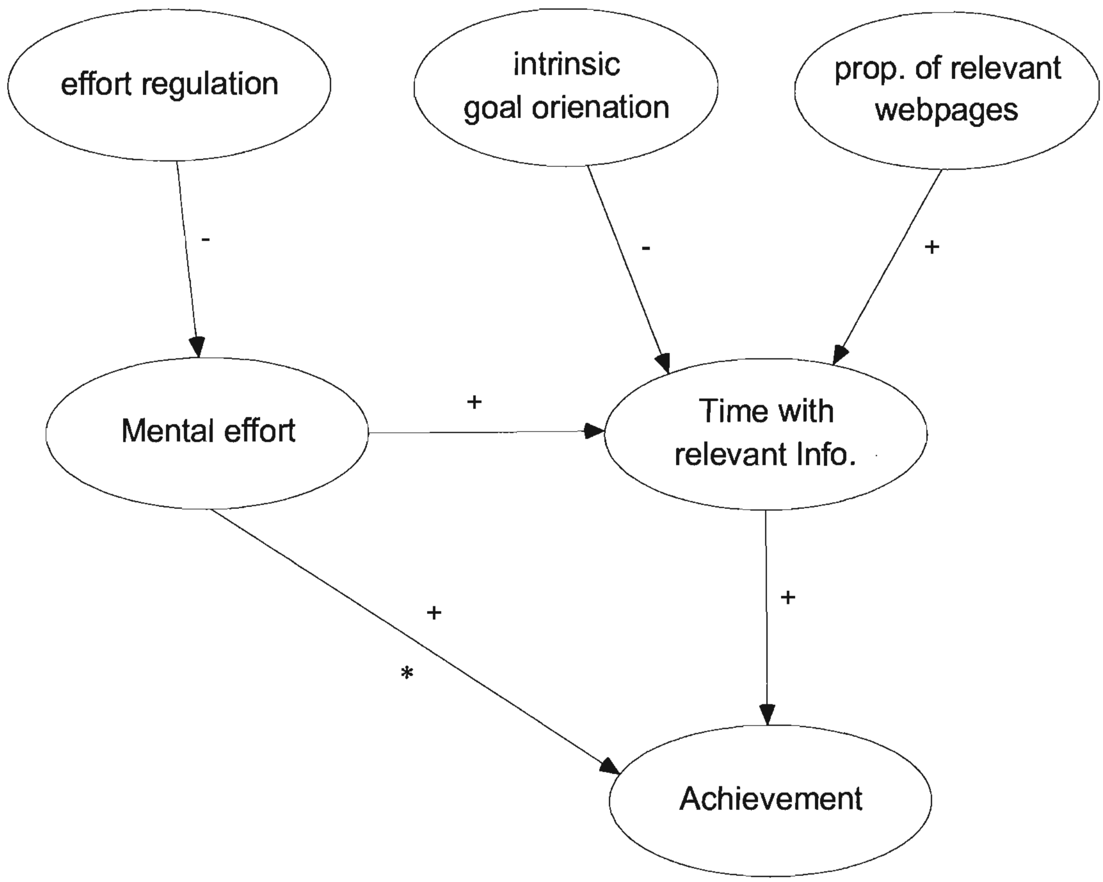

Figure 7. Final model of the relations among achievement, increases in mental effort, time spent with relevant information, learner characteristics, and navigation behaviours. Mental effort refers to the frequency of increases in mental effort. The signs of the paths represent the relation between the variables. The path labeled with an asterisk (*) indicates a mediated path; specifically, the positive relation between the frequency of increases in mental effort and achievement was mediated by time spent with relevant information.

Does time spent with relevant information mediate the relation between increases in mental effort and achievement? As expected, a greater proportion of time spent with relevant information mediated the positive relation between the frequency of sudden increases in mental effort and achievement. I also expected that higher levels of overall mental effort may facilitate learning to a greater extent if learners exhibit fluctuation in their mental effort in comparison to stable high levels of mental effort. The average change in pupil size (ACPS) measured the stability in mental effort throughout the Internet session and the subjective rating of mental effort was used as a measure of the overall level of mental effort (high vs. low). Contrary to my predictions, the interaction between level and stability of mental effort was not significant; however, there was a significant main effect of ACPS for achievement. Greater changes (or less stability) in mental effort while navigating the Internet predicted higher achievement scores.

Do navigation behaviours account for variability in time spent with relevant information? A greater proportion of relevant webpages accessed was associated with a greater proportion of time spent with relevant information, supporting my hypothesis. Contrary to expectations, however, the number of search engines used, number of specific and general searches conducted, and the maximum number of windows opened were not related to time spent with relevant information. The lack of relation was likely due to a lack of variability observed for the navigation behaviours.

Do self-regulated learning characteristics account for variability in time spent with relevant information and the frequency of increases in invested mental effort? It was hypothesized that a greater tendency to adopt an intrinsic goal orientation and regulate one's effort would be positively associated with time spent with relevant information and the frequency of increases in mental effort. Surprisingly, a lower tendency to adopt an intrinsic goal orientation predicted a greater proportion of time spent with relevant information, and a greater tendency to regulate effort was associated with fewer increases in mental effort while learning from the Internet. In addition, intrinsic goal orientation was not related to increases in mental effort and effort regulation did not predict time spent with relevant information. Self-regulated learning characteristics also did not account for variability in the proportion of webpages accessed which exceeded 60 sec or achievement directly.

Do cognitive factors account for variability in time spent with relevant information and the frequency of increases in mental effort? None of the cognitive factors (distractibility, cognitive style and WM control) were significant predictors of either time spent with relevant information or the frequency of increases in mental effort. Moreover, the cognitive factors were not associated with the proportion of relevant webpages accessed which exceeded 60 sec or with achievement directly.

Discussion

The Internet has become a prevalent educational resource for learners of all ages, and has the potential to develop not only knowledge within various domains but also to enhance self-regulatory skills. However, some novices have difficulty guiding their own learning when using this open-ended resource. The current study was designed to enhance an understanding of individual differences in behavioural processes when novices use the Internet. I found that although novice adults on average benefited from their Internet navigations, some learners were more successful than others in terms of achievement. The major determinant of success was the time learners spent with relevant information. Moreover, a greater frequency of increases in mental effort had an indirect effect on achievement; specifically, time spent with relevant information partially mediated the positive relation between frequency of increases in mental effort and achievement. To be able to identify appropriate supports, it is important then to determine factors that influence time spent with relevant information and frequency of increases in mental effort when using the Internet. I found that some navigation behaviours (i.e., proportion of relevant webpages accessed) influenced time spent with relevant information, and components of self-regulatory learning impacted time spent with relevant information and the frequency of increases in mental effort. The following provides a discussion of these factors as well as suggestions for potential supports for novices when using the Internet.

Novices' Success When Using the Internet

Consistent with Desjarlais and Willoughby (2007), on average, novices in the current study benefited from using the Internet for 20 min to learn about the assigned topic. Specifically, learners who navigated the Internet for 20 min to learn how tropical cyclones form scored higher on an achievement test in comparison to their peers who completed the same post-test without exposure to the Internet. In contrast, however, some researchers have indicated that novices do not benefit from their search for information on the Internet in comparison to a control group. For example, Willoughby and colleagues (2009) asked participants to complete a written assignment corresponding to a low knowledge domain (either environmental planning or biology). While some participants were able to search the Internet for information prior to completing the task, the remaining learners completed the assignment without access to the Internet. There was no difference in subsequent recall performance among these two groups. The lack of significance may have been due to the difficulty associated with searches. Some novices in Willoughby et al.'s study commented that the biology topic required learning and writing about scientific terms, which made it difficult to not only understand the content but also to accurately explain the concepts. In addition, some novices expressed that there was a lack of relevant information on the Internet and expert students in biology even indicated that it was difficult to find information on the Internet regarding the biology topic.

Learners in the current study, in contrast, indicated that they were able to find relevant information with very little difficulty. By simply entering the general concept "tropical cyclone" learners were provided with multiple webpages that contained relevant information, regardless of the search engine used. The relative ease for retrieving relevant information may have reduced the time spent searching for relevant webpages for learners (in comparison to novices in Willoughby et al.'s (2009) study), allowing for more time to be spent studying relevant information. Moreover, learners were assigned an open-ended task, which may have also contributed to their success. There were multiple steps involved in how tropical cyclones form, as well as multiple precursors to formation. In other words, there were multiple ways to describe how tropical cyclones form and learners, therefore, were not required to retrieve or learn the same information as their peers to perform at a similar level on the achievement test. In fact, Bilal (2000; 2001) found that open-ended assignments (which have multiple possible answers) were associated with higher achievement scores than fact-based (single answer) search tasks. Therefore, the availability and accessibility of information on the Internet appears to be a determining factor in novices' success. Exposure to information on the Internet may be sufficient for learning for novices, on average, at least for open-ended searches within open-ended environments.

The main focus of the current study, however, was the variation in novices' success. Although, on average, novices benefited from using the Internet, there was great variability in achievement scores (14% to 75%). In fact, some learners still scored within the range of the control group, or had guessed on many questions within the achievement test. To be able to develop supports for learners when interacting with the Internet or complex learning environments, it is important to understand what may account for this variability in learning. In the present study, I predominately explored time spent with relevant information.

Does Time Spent with Relevant Information Predict Achievement?

Learners performed better on post-tests when they had spent a sizeable portion of their time studying relevant information across initial webpage visits and revisits. This relation was over and above cognitive capacities (i.e., reading comprehension, general mental ability), knowledge level (topic and Internet knowledge) and motivation for the task. Taking into account previous research (Lawless et al., 2003; Rawson, Dunlosky, & Thiede, 2000), this effect was not that surprising. By studying relevant information for a longer period of time learners may have been exposed to a greater number of facts in comparison to peers who spent less time with relevant information (Barnett & Seefeldt, 1989). Exposure to a higher quantity of relevant information may have facilitated the development of schema, by creating more connections within their schema for the topic, thus facilitating a boarder knowledge base. Alternatively, learners could have focused on a small selection of relevant passages, resulting in the creation of few but strong connections within their schema and a deeper understanding of the topic. In either case, achievement would likely have been facilitated.

Novices did not have difficulty retrieving sources that contained relevant information. All participants accessed and stayed on at least one relevant webpage for longer than 1 min. Interestingly, 44 participants (52% of the sample) did not spend longer than 1 min on any irrelevant webpage they accessed. Thus, a sizeable percentage of participants were able to at least identify the relevancy of webpages at a global level (relevant versus completely irrelevant). The main challenge when guiding one's learning on the Internet then was not in retrieving or identifying valuable resources (although this may have been a problem for select participants or webpages), as suggested by Downing et al. (2005) and Marchionini et al. (1993). Instead, the main difficulty for learners overall was spending time with relevant information on relevant webpages. Therefore, the presence of extraneous information appeared to direct attention away from relevant content for some reason. In some instances, novices' focus may have been diverted by more interesting information, either intentionally or not. Indeed, some learners followed hyperlinks or attended to passages within a webpage that obviously did not relate to the assigned topic. During other instances, novices may have been unable to distinguish irrelevant from relevant passages. Mayer and colleagues (2001) suggested that when novices are faced with extraneous information thought to be relevant, they try to relate the irrelevant content to the relevant information which interferes with the development of a deeper understanding of the relevant material. Since learners in the current study were not required to rate the perceived relevancy of the passages they attended to, the two instances described cannot be identified with certainty within individual navigations. Follow-up procedures utilizing the eye tracker and either the think aloud procedure or post-navigation interviews are necessary to distinguish between instances when learners become distracted versus instances when they have difficulty identifying the relevancy of information.

Furthermore, approximately 45% of the participants in the current study revisited previously accessed relevant information. This behaviour appeared to be a deliberate strategy given that they either had to retrieve the previously accessed webpage from the search results page, or reopen a webpage previously minimized in another window. However, the time spent with revisited relevant information was relatively low. This was initially surprising given that research focusing on learning from closed learning systems has presented a positive effect of revisiting information for achievement (in comparison to not revisiting information). This strategy has been suggested to increase the number of facts learned, such that learners acquire additional information that was missed during the initial reading, or strengthen weak connections (Lawless & Brown, 1997). Researchers have suggested learners need to read through a variety of information on the Internet before being able to distinguish between relevant and extraneous information. Once being exposed to repetitious information, learners may be able to recognize that the information they accessed earlier during their navigation was relevant, and thus they return to learn this content (Junivo, 2006; Wen, 2003). Alternatively, learners may recognize relevant information during initial visits, and return to previously accessed information to verify their mental model, to retrieve forgotten information, or to revisit challenging information after developing a base understanding. Revisiting information may also enable learners to compare and contrast relevant content, facilitating the discovery of connections between segregated information (Lawless & Brown, 1997). The common theme, regardless of the motivation behind this behaviour, is that revisiting facilitates the formation of schema.

In the context of the current study, however, revisiting may not have been necessary to develop an understanding of the assigned topic. Similar relevant information was easily accessed through a variety of webpages, eliminating the need to return to previous webpages. Thus, missed content could have been noticed or confusing information could have been clarified while reading a subsequent relevant webpage. In contrast, in closed hypermedia environments information on each of the pages typically is novel. In this situation, individuals are required to return to previously viewed pages if they wanted to further their understanding for particular content. When using the Internet, accessing multiple pages may be a substitute for revisiting, and in fact, a greater number of relevant webpages accessed overall was a significant predictor of time spent with relevant information. It would be interesting then for future research to investigate the motivation for not revisiting information.

The current study's findings have important implications for supports given that the first step to forming a coherent mental model of information requires the selection of information to study (Mayer, 2005). Some novices may require additional scaffolding to facilitate on-task behaviour, and within the classroom providing supports may be relatively easy. First, students may collaborate with peers. Lazonder (2005) discovered that college students who searched for and retrieved information from the Internet were able to answer a greater number of the assigned questions successfully as well as correct wrong answers more often when they completed the searches with a partner rather than alone. According to Lazonder, when working in pairs, students must come to a consensus regarding the relevance of the material found on the Internet for answering the question at hand. It might be expected that less knowledgeable learners would exhibit the best results when they have the assistance of more knowledgeable peers to find the correct answer on the Internet.

In addition, researchers have consistently shown that judging the relevancy of information is facilitated by increases in the level of domain knowledge (Downing et al., 2005; Marchionini et al., 1993; Spilich et al., 1979; Symons & Pressley, 1993). For example, Symons and Pressley instructed novices and experts to search printed text materials for relevant information. Learners with high domain knowledge identified the target information more often than those lacking domain knowledge, even though the novices scanned the pages that contained the relevant information. During collaborative learning situations, experts may be able to identify relevant information for novices and assist in the maintenance of on-task attention. Alternatively, instructors may provide novices with a list of suggested webpages which contain minimal extraneous content (Kafai & Bates, 1997). This would reduce any guess work involved in distinguishing between relevant and irrelevant information and limit diversions away from relevant information. If novices are not forced to make decisions regarding the information they will study, at least initially, then they may be able to develop a knowledge base to successfully guide subsequent decisions regarding content.

The major disadvantage with such supports, however, is that they require the learners' behaviour to be externally regulated. This is counter to the strength offered by the Internet, specifically, that learners are able to guide their own learning when using this resource. It is important then to also identify general techniques or strategies that could be taught to learners to help separate relevant and irrelevant information and ignore distractions when using the Internet on their own.

Does Time with Relevant Information Mediate the Relation between Increases in Mental Effort and Achievement?

Learners who perceived the task as more difficult were more likely to report investing a higher level of mental effort overall. However, subjective level of overall mental effort was not associated with achievement scores. On average, novices indicated that learning how tropical cyclones form from the information they accessed on the Internet was relatively easy, suggesting that a high overall level of mental effort may not have been necessary to do well. Although other researchers have found that learners who invest greater mental effort within a particular task typically outperform less engaged peers (e.g., Corbalan et al., 2008; Hassenzahl & Ullrich, 2007; Muller et al., 2008), the results of the current study are not necessarily in contradiction to this finding. Novices in the present study were required to navigate the Internet for 20 min without any restrictions. While this was important for understanding novices' natural behavioral processes, the learner-control did result in large variability in learning experiences and was a tradeoff for experimenter control over the level of task difficulty. Some navigation paths may have required a higher level of effort than others to be successful. Taking this into account, it is not surprising that overall level of mental effort was not related to achievement. In situations where learners' experiences differ, the difference between required and actual level of invested mental effort may be an important indicator of achievement; however, this question is beyond the scope of the current study and should be addressed in future analyses.

Subjective ratings may provide an insight into overall level of mental effort, but this measure does not address fluctuations in mental effort while navigating the Internet. Pupillary changes across the Internet session within participants were explored to gain a deeper understanding of the relation between changes in mental effort and achievement. The mean change in pupil size was positively related to achievement, such that greater fluctuations in mental effort (or less stability overall) was associated with higher levels of achievement regardless of the level of subjective mental effort. Learners who reported investing higher levels of mental effort overall may have benefited from fluctuations in their effort by avoiding cognitive overload. At the same time, when overall level of mental effort was reported to be low by participants, fluctuations in effort may have prevented disengagement from the task.

The average pupillary changes, however, did not provide an understanding of the increases in effort (as accompanying decreases canceled out increases when calculating an average). Thus, the frequency of increases in mental effort from one minute to the next was considered, which was positively related to both achievement and time spent with relevant information. More interesting, however, time spent with relevant information partially mediated the relation between the frequency of increases in mental effort and achievement. Momentary increases in mental effort may have enhanced attention to relevant information among novices. Limited cognitive resources are available to be distributed among on-task and off-task behaviours. The distribution of such resources is said to be determined by involvement in the task (Paas et al., 2005). When learners try hard to complete the task they may allocate greater cognitive resources to task-relevant procedures (Paas, Tuovinen, van Merrienboer, & Darabi, 2005). For the current task, where learners were assigned to learn about how tropical cyclones form, task-relevant procedures would be reading information related to the steps and precursors involved in tropical cyclone formation. Alternatively, attending to relevant information may have elicited increases in mental effort. Information pertaining to tropical cyclogenesis may have resulted in greater increases in mental effort than attending to irrelevant information. It would be interesting then to examine in future analyses the information attended to just prior, during, and immediately following the increases in mental effort.

Learning as a result of simply exposing novices to information may be limited by their involvement in the task. Motivating students may be a potential support for learning from the Internet. In fact, motivation to complete the tasks, although included as a control variable, was positively associated with the frequency of increases in mental effort.

According to Paas et al. (2005) "motivating students to achieve in e-learning environments is a topic of practical concern to instructional designers, and of theoretical concern to researchers" (p. 27). Although influences on motivation were not investigated in the current study, previous research has identified that task-related variables impact mental effort. Such factors include perceptions regarding the importance of the task, value of engaging in the task, difficulty of the task and mental effort required to complete the task (Cennamo, 1993; Pintrich & Schrauben, 1992; Salomon, 1983). In terms of perceived mental effort, Cennamo (1993) found that learners did not invest effort if they perceived it as a waste of energy or unnecessary for success. In other words, learners refrained from exerting effort when the task appeared too difficult such that success could not be obtained even if they tried harder, or if the task was perceived as easy such that it could be completed with little effort. In addition, the allocation of effort toward task-relevant goals may also be influenced by incentives, goal orientation (although not supported by the findings in the current study), and individual personality differences (Fisher & Ford, 1998). It would be interesting to investigate learners' perceptions of the required mental effort when navigating the Internet and how these perceptions influenced actual level of invested mental effort.

The frequency of increases in mental effort was measured in the current study by using changes in pupil diameter from one minute to the next within the Internet navigations. There is a large body of literature demonstrating the relation between pupil dilation and effort expenditure. For example, pupil dilation has been used as an indicator of processing demands within the language and reading literature (Beatty & Wagonor, 1978; Hyona, Tommola, & Alaja, 1995; Just & Carpenter, 1993; Schluroff, 1982;

Stanners, Headley, & Clark, 1972; Wright & Kahneman, 1971), attention literature (Beatty, 1988) and individual differences literature (Ahern & Beatty, 1979, 1981). The current study has extended this list to include learning and hypermedia. Pupillary measures were validated in the current study through the use of the working memory control task. Pupil diameter increased as a function of the number of words required to recall. Therefore, this objective and nonintrusive measure may provide information regarding the processing demands within hypermedia.

Do Navigation Behaviours Account for Variability in Time Spent with Relevant Information?

Participants accessed a combined value of 397 unique webpages (including relevant and irrelevant sources). Although learners navigated within the same learning environment and with similar search terms, they had unique experiences. The webpages viewed played a role in the time spent with relevant information. In general, a greater number of relevant webpages and a lower number of irrelevant webpages facilitated time spent with relevant information. Multiple relevant resources facilitated time with relevant information, indicating that switching resources seemed to facilitate the maintenance of on-task behaviours. Learners were provided with the general goal of learning how tropical cyclones formed, and this may have become salient whenever learners accessed a new resource. Reminding themselves that they were to learn how tropical cyclones form may have sustained focus for the task. Azevedo and Cromley (2004) have indicated that restating the task goal is a common strategy among novices. As such, learners may actively direct behaviour or strategies to achieve the goal, ignoring irrelevant information.

Past research examining the impact of multiple resources on learning suggests that the use of multiple sources facilitates deeper information processing. For example, Wiley and Voss (1999) compared the performance of individuals who were provided with multiple sources of information and those who exposed to the same content but organized within a single resource. Individuals who used the segregated sources created more integrative essays on the topic, demonstrating a deeper understanding of the information (also see Voss & Wiley, 1997). Similarly, Perfetti, Britt, and Georgi (1995) observed that knowledge became progressively more detailed with studying of subsequent resources.

However, when considering only the webpages accessed for longer than 60 sec, the number of irrelevant webpages accessed was the only significant predictor of time spent with relevant information. When coding the relevancy of passages on the various webpages, it was apparent that there was repetition of concepts pertinent to the formation of tropical cyclones. Participants who accessed multiple relevant webpages may have been exposed to the same information as participants who chose to learn from a few main webpages. The disregard of irrelevant webpages had a positive effect on time spent with relevant information. This is not surprising given that time spent with any of the passages on such webpages would detract from time spent with relevant information. One particularly striking outcome in the present study was the ability of novices to distinguish between valuable and irrelevant resources. Although all participants accessed irrelevant webpages, almost half of the participants did not spend more than one minute on such pages. Since the names of hyperlinks either on search results page or within webpages were sometimes ambiguous and did not provide sufficient information to make an accurate judgment regarding the relevancy of the webpages (e.g., tropical storm risk), learners would need to view the webpage's content to determine its relevancy. Thus, it makes sense that learners would access some irrelevant webpages during their navigation. In hindsight, the relative ease for judging the relevancy of a webpage was likely due to the structure of the webpages, such that headings (e.g., Tropical Cyclone Formation) were often available to guide learners' attention to relevant information. Although one of the criticisms pertaining to the Internet has been its lack of structure and organization (e.g., Willoughby et al., 2009), this was not evident within the current study. In fact, the webpages seemed to be structured in a manner consistent with the task's goal, a factor found to facilitate learning of a topic (Shapiro, 1999).

Although there were large individual differences in the information exposed to during Internet navigations as a function of the webpages accessed, there was little variability in navigation behaviours such as the number of search engines, maximum number of windows opened simultaneously, and number of specific/general search terms used. The vast majority of participants used only one search engine (predominantly Google), had only one window open at any one time, conducted one specific search, and conducted either one or no general searches. Thus, participants in the current study searched for information in very similar manners, making relevant information easily available to all participants. As search engines become increasingly more efficient and easier to use, they support learners, especially novices, in their search for information (Willoughby et al., 2009). Simply using the major relevant terms related to the topic resulted in a list of relevant webpages from which to search. In addition, the major search engines seemed to provide very similar results, and thus switching search engines may not have been that useful.

A shift in search behaviours may only arise when the results from a particular strategy have been exhausted. Anecdotally, some learners searched for visual representations of how tropical cyclones formed. However, there were very few images which depicted the steps involved in how tropical cyclones formed. Instead, participants were provided with webpages containing images of real tropical cyclones or damages associated with past tropical cyclones. Even after revising their search terminology, participants were rarely successful. In the end, all participants returned to a textual-based search. If the visual-based search had been successful learners may not have shifted their technique. Moreover, since the vast majority of participants conducted a successful search on their first attempt, there was not a necessity to shift strategies. Future research is necessary to investigate how one's experiences (failures and successes) during an Internet search effect subsequent behaviours.

Surprisingly, only a few learners in the current study had more than one window open simultaneously. This strategy seems very efficient for maintaining easy access to webpages. Learners may keep a webpage open while navigating through other webpages in another window. Instead of using the back button or reselecting a webpage from the results list, the webpage would simply be maximized for viewing. Since completion of the current study, however, Internet Explorer has updated its features. Users are now provided with a Tab feature such that a single window may be used but multiple webpages may be opened on their own page, indexed by a Tab (similar to workbooks in Excel). It would be interesting to explore how such features impact on the manner in which learners use the Internet and time spent with relevant information on initial viewings and revisits.

Learner Characteristics: Predictors of Time with Relevant Information and Increases in Mental Effort

Not all novices have difficulty learning from the Internet, giving rise to the question, who should supports be targeted at? Overall, there were very few significant predictors of time spent with relevant information and the frequency of increases in mental effort. Self-regulated learning characteristics were important factors, whereas associations with cognitive-related factors did not emerge.

Do self-regulated learning characteristics account for variability in time spent with relevant information or increases in mental effort? Learners who reported a tendency for adopting an intrinsic goal orientation within the average university course were observed spending *less* time with relevant information. The direction of the relation was surprising at first given that researchers have often reported that intrinsic goal orientation facilitates academic achievement (Ames, 1992; Greene & Miller, 1996; Pintrich, 2000; Pintrich & Garcia, 1991), suggesting greater attention to goal-relevant information. Learners who adopt an intrinsic goal orientation are motivated by the desire to learn something new, are not concerned with the amount of time or effort required to learn the content, and regard their mistakes as learning opportunities (Lynch & Dembo, 2004). Given these traits, such learners in the current study may have made the effort to learn not only about how tropical cyclones form but also about tropical cyclones in general, formulating a broad schema. Their devotion to mastering the content may have overshadowed the specific goal set by the experimenter. Thus, time spent with information irrelevant to the task at hand may have been regarded as valuable and did not elicit a shift in attention to relevant information. A recognition test specific to the topic may not have captured the breadth of their newly acquired knowledge. Indeed, learners who reported a greater tendency to adopt an intrinsic goal orientation had a similar frequency of increases in mental effort as individuals who typically do not adopt an intrinsic goal orientation. Therefore, when presented with a specific, assigned goal and a limited search time, a strong intrinsic goal orientation may negatively influence time spent with relevant information. Intrinsic goal orientation, on the other hand, may be beneficial in learning of a domain rather than a specific topic or when there are no time restrictions. Additional research is necessary to test this hypothesis.

Given that the Internet may be a challenging task when domain knowledge is low, it was expected that learners may need to be skilled at regulating their effort to be successful. However, typical effort regulation (the ability to persist on tasks despite challenges or boredom) was not related to time spent with relevant information when using the Internet. In support of this finding, Chen (2002) found that although effort regulation had a positive effect on learning during a lecture, it was not related to learning during computer-based assignments. In addition, Hsu (1997) found that effort regulation was not related to performance in distance learning. Moreover, Azevedo et al. (2004) used the think aloud procedure to gain insight into the cognitive processes of novices while learning from a hypermedia environment. In the condition similar to the current study, in which learners were instructed to learn about a particular topic for an immediate test of knowledge, 12 of the 17 participants verbalized strategies relating to time/effort regulation. Therefore, learners may be inclined to regulate their effort when using computer-based resources even though they may not regularly do so in academic-related contexts. The current study does offer some support for this claim. Lower scores on general effort regulation were associated with a higher frequency of increases in mental effort. Thus, learners who typically do not regulate their effort during academic courses increased their effort more often during the Internet navigation in comparison to individuals with higher effort regulation scores. This may have eliminated any differences in time spent with relevant information that could have been attributed to effort regulation if using traditional resources.

The increases in mental effort may be due simply to the presence of the computer. Researchers have indicated that students tend to be more motivated to complete a task when information is presented using a computer compared to paper-based materials (Shuell & Farber, 2001; Small & Ferreira, 1994; Yang, 1991-1992). When university students, for example, were asked to rate their motivation for using technology in their courses, almost three-quarters of the students agreed that the technology increased their motivation, interest, and attention during the lectures (Shuell & Farber, 2001). Similarly, in empirical examinations of student motivation, students who were assigned to study information from the computer indicated higher levels of motivation compared to students studying from a paper-based version (Small & Ferreira, 1994; Yang, 1991-1992). Researchers have indicated that learner-control is primarily responsible for the increase in motivation that computers tend to elicit (Kinzie, 1990; Kinzie, Sullivan, & Berdel, 1992; Milheim & Martin, 1991; Steinberg, 1989). Learners can avoid and access information of their choosing. Interest brought about by situational factors, in this case the computer, also may impact reading comprehension. There is consistent evidence that as individual interest increases, recall of information also increases (Lawless et al., 2003; Lawless & Kulikowich, 1998; Schiefele, 1991). The proposed relation between effort regulation when using the computer, motivation, and Internet navigations warrants further investigation.

Do cognitive factors account for variability in time spent with relevant information or increases in mental effort? Within the current study, three cognitive factors were explored as predictors of time spent with relevant information and frequency of increases in mental effort: cognitive style, WM control, and distractibility. I also explored if the frequency of increases in mental effort was especially important for individuals with low WM control or high distractibility regarding time spent with relevant information. These factors, however, did not account for variability within time spent with relevant information or mental effort, and the interactions were not significant. It should be noted that the lack of significance was not because of lack of variability in the predictors or outcome variables.

First, providing control over learning enables individuals to find webpages that present information in a manner that matches their learning preferences. Although the Internet is often regarded as typically presenting information in a nonlinear, unstructured fashion, the webpages accessed by learners within the current study contained, for the most part, some structure – at the very least headings before a passage. For example, the tropical cyclone entry on the Wikipedia website was accessed the most across participants (70 participants accessed this webpage). This webpage contained headings (e.g., *Mechanics*, *Formation*), subheadings (e.g., *Factors* under the heading *Formation*), a table of contents, introductory paragraphs, etc. This may have been particularly useful for field dependent learners who tend to prefer a more structured environment (Ford & Chen, 2001). Researchers have found that both field-dependent and independent learners perform well when information is presented in such a fashion (Douglas & Riding, 1993; Riding & Sadler-Smith, 1992). This may explain why differences were not observed for the time spent with relevant information as a function of cognitive style.

It was not the case that learners were not exposed to any distractions during their navigations. Only 32% of the webpages accessed contained information directly relevant to the task. In addition, relevant webpages did contain potential distractors, such as pictures of the damage associated with tropical cyclones, and information related to how tropical cyclones are named or emergency procedures during a cyclone. However, learners were assigned to search the Internet for information on a specific topic for an immediate recognition task, and were given 20 min to do so. With a clearly defined goal in mind, both learners of high and low distractibility may have tried to meet these demands. Given that they would be tested on what they learned immediately after the search, they would have been aware that any time spent off-task would interfere with the time available to complete the task goal. Moreover, learners were aware that their actions on the Internet were being recorded, which may have helped to regulate behaviour.

Alternatively, the high perceptual load associated with the Internet may have eliminated individual differences in distractibility. According to Lavie (2005; Forster & Lavie, 2007), perceptual load refers to the relevant stimuli present on-screen, with high perceptual load corresponding to either (a) the presence of a large number of relevant stimuli (e.g., six or more) or (b) when a few number of relevant items elicits high demands on attention (e.g., response required when a blue square and red circle are present). Webpages typically consist of a variety of stimuli presented to learners simultaneously, including but not limited to sections of textual information, illustrations, advertisements, moving or flashing objects, visit counters, and hyperlinks. Thus, learners may experience high perceptual load when navigating the Internet. According to the Perceptual Load Theory (Lavie, 1995; 2005), perceptual processing has limited capacity. In general, when the perceptual load is low, the remaining resources will be unintentionally used for the perception of task-irrelevant stimuli. On the other hand, when perceptual load is high, requiring the full perceptual capacity, there is no remaining resources for the perceptual processing of task-irrelevant stimuli.

Forster and Lavie (2007) investigated the interaction of perceptual load and level of distractibility in everyday life on the ability to identify the presence of a target among non-target and distractor stimuli. When perceptual load was low, highly distractible learners took longer to correctly identify the target stimuli than less distractible learners. However, there was no difference in accuracy as a function of distractibility when perceptual load was high. Moreover, both groups performed better under high in comparison to low perceptual load. Therefore, if we regard the Internet as posing high perceptual load on learners then participants would have attended to relevant information for similar amounts of time regardless of distractibility level. Similar findings come from the ADHD (attention deficit hyperactivity disorder) literature. Shaw and Lewis (2005) found that children with ADHD exhibited less off-task behaviours when completing a task on a computer in comparison to paper-based versions. One theory of ADHD indicates that off-task behaviour associated with ADHD may be a result of low physiological arousal, and as a result individuals seek out alternate stimulation (Antrop, Roeyers, Van Oost, & Buysse, 2000). Overall then, the webpages accessed then may have provided highly distractible learners with high perceptual load and/or an adequate level of stimulation.

It was expected that WM control would influence both the frequency of increases in mental effort and time spent with relevant information. There is evidence that WM control contributes to the performance of many cognitive tasks, and for complex cognitive processes such as language comprehension (Baddeley, 1986). Given that mental effort may be considered a motivational behaviour (Paas et al., 2005), WM control may not impact on how hard learners try when completing a task. Instead, WM control may be important for perceptions of task difficulty and cognitive load. In addition, the findings suggest that good WM control does not act as a support when domain knowledge is low. Indeed, Kaakinen and colleagues (2003) found that novices recalled more goal-relevant than goal-irrelevant information regardless of WM control. Interestingly, they also approached the reading of the texts in similar manners, slowing down their reading speed when information appeared to be relevant. In contrast, differences as a function of WM control were observed when domain knowledge was high.

However, the interpretation of the findings as well as the potential implications should be interpreted cautiously. Within the cognitive literature, the OSPAN task to measure WM control suggests that learners obtain a minimal score of 85% on the mathematical calculation component to ensure that learners were not trading off between solving the operations and rehearsing the words (e.g., Conway & Engle, 1996; Unsworth, Heitz, Schrock, & Engle, 2005). However, none of the participants in the current study met this criterion. The lack of significant effects associated with this cognitive factor may be attributable to the lack of validity of the OSPAN task within the current study rather than to the individuals' WM control. Although instructions were made clear to the participants in the current study that accuracy on both the operations and word recall were important, researchers have incorporated additional techniques to increase accuracy for the operations. For example, Gerrie and Garry (2007) had the computer warn participants when they dropped below 85% on the operations. Another factor may have been that learners were required to press the Z and M buttons on a keyboard to indicate true or false. Because this association is not intuitive, learners may have inadvertently pressed the wrong keys. Some learners scored well below chance on the operations, suggesting that this may have been the case. It may have been more efficient to use the F and T keys. Indeed, researchers have created versions of the task where learners click a button corresponding to their answer using the mouse. Follow-up research is necessary to be certain as to whether WM control does impact on Internet navigations and corresponding changes in mental effort.

Additional Analysis

Learner characteristics were explored as predictors of the variability in the proportion of webpages accessed exceeding 60 sec. None of the learner characteristics were related to this difference in navigations. This result is surprising given that intrinsic goal orientation was negatively related to time spent with relevant information. This suggests that individuals may be moving around on the Internet in a similar way, but what they attend to when on webpages is driven by an general adoption of intrinsic goal orientation.

Reflections on the Current Study

Limitations of the current study. It is important to note that the interpretation of the findings is limited by the sample size to predictor ratio. Although a relatively large number of participants were involved in the current study in comparison to typical hypermedia literature [e.g., Willoughby et al. (2009) observed only 20 participants' Internet navigations], multiple variables were included in many of my analyses. Specifically, five variables were included as covariates in every analysis, reducing the degrees of freedom available for the predictors of interest. Although some of the analyses were rerun with a slightly larger sample size and results remained unchanged, replication of the findings is necessary. In addition, the size of the sample influenced the choice of statistical analyses used. Although the graphical representation of the hypotheses (see Figure 1) suggests that a path analysis may have been appropriate, the current study did not contain a sufficient sample size to carry out this procedure.

Second, the generalizability of the findings is limited by the nature of the task and the age of participants. Undergraduate students were assigned to search the Internet regarding a specific topic within a short amount of time. Learners accessed relatively few webpages in comparison to other studies (e.g., Willoughby et al., 2009), conducted very few unique searches, and typically made use of a single search engine. The lack of variation in behaviours may have been due to the relatively short period of time learners had with the Internet. As previously discussed, the fast search task may have also contributed to the unexpected findings regarding self-regulated learning components. Conclusions then regarding longer navigations cannot be formed based on these findings. However, one may speculate that although learners may numerically access more webpages during longer searches, there may be a high correlation among behaviours between fast and prolonged searches. Moreover, the findings may only be relevant to assigned tasks, where the goal is generated by an external source. It is unknown if the navigation behaviours would be consistent with how individuals navigate the Internet pertaining to self-generated searches.

Moreover, the implications of the study may not extend beyond the young adult population. Children and older adults differ in cognitive capacities in comparison to young adults. For example, processing becomes more efficient with age (Case, Kurland, & Goldberg, 1982), and short-term storage capacity increases (Dempster, 1981). In addition, there is evidence that older adults may be more susceptible to distractions than younger adults (McDowd & Craik, 1988), and that they may have greater difficulty dividing their attention between simultaneous tasks (McDowd & Shaw, 2000). In addition, older adults may be under greater stress when using the Internet. It is unclear whether the benefits associated with using the Internet when domain knowledge is low may extend to such populations, or whether individual differences may be more prevalent. Additional research is necessary to understand how other age groups navigate the Internet.

Finally, the main interest in the current study was to examine changes in mental effort *within* participants when navigating the Internet. The frequency of sudden increases in pupil diameter which exceeded one half standard deviations was utilized. Within the literature using pupillary responses as an indicator of cognitive processing, researchers have compared the magnitude of changes in pupil size in relation to a baseline measure to draw conclusions on which tasks were more mentally demanding (e.g., Beatty, 1966;

Hyona et al., 1995). Since I examined changes in effort within a task and did not compare the mental effort expended between tasks, a baseline measure of pupil size was not necessary. Without a baseline measure of pupil size, however, conclusions as to the overall level of mental effort invested could not be inferred from the pupil data. Information regarding the overall level of mental effort in the current study was obtained through self-report. Subjective level of mental effort was not a significant predictor of achievement or time spent with relevant information. This finding suggests that a subjective measure of overall level of mental effort may not be a valuable indicator of mental effort when learners access a variety of resources varying in comprehensiveness and difficulty. It is unknown as to which factors during the Internet session learners considered when rating their invested mental effort level. In contrast, the average change in pupil size (a measure of stability in mental effort) was positively related to achievement. This finding suggests that when navigating the Internet novices on average benefited when greater fluctuations in their effort occurred. To support these findings, follow-up research could manipulate the level of task difficulty or required mental effort and determine whether greater changes in mental effort throughout completion of the task are beneficial for all levels of task difficulty.

Strengths of the current study. Although the recording of gaze has a vast history (e.g., Beatty, 1972; Hess & Polt, 1960; Kahneman & Beatty, 1966), it has rarely been used to observe how novices guide their learning when using the Internet. Eye fixation data can reflect attention and shifts in attention to stimuli, and thus provide data regarding the information learners attended to, revisited, and ignored on a particular webpage. The current study then has filled a gap in the literature regarding novices' separation of goal-relevant and irrelevant information during complex learning environments. According to Mayer's (2001) theory of multimedia learning, learners first select information for processing. This information then enters working memory where it is processed and integrated with prior knowledge to form a coherent mental model. Much of the hypermedia and multimedia research have focused on defining supports for learners during the encoding process. However, the findings of the current study denote that learners who obtained low (even failing) achievement scores attended to relevant information for less time. Therefore, greater focus may be warranted on the first step for learning – the selection of information. A greater understanding of why some novices have difficulty selecting appropriate information, while others are successful, is important for facilitating self-guided learning.

In addition, pupil dilation provided information about changes in mental effort invested *within* a particular task. Although the exploration of the changes in mental effort within a task, rather than between tasks, is not a novel area of research, it has not been explored when using the Internet. The current study then has extended the use of this measure. Eye tracking has also provided interesting information about individuals' Internet navigations as well as the changes in invested mental effort imposed by their navigations.

There may be concern that wearing the eye tracking device may have impacted on the naturalness of participants' navigation searches – because of the novelty of the device and the knowledge that their actions are being recorded. In the current study, eye tracking required participants to wear headgear while completing the WM control task (OSPAN) and when navigating the Internet. Participants were able to become accustomed to the device while completing the WM control task, which lasted about 10-20 min. Participants' view of the computer screen (or any part of their environment) was not obstructed by any piece of the equipment; moreover, both eye and head movements were not restricted following the calibration (see Appendix N for a picture of the eyetracker). Participants were able to sit and move naturally while navigating the Internet (i.e., they were able to slouch, lean forward or backward, or rest their chin on their hand). Indeed, participants typically moved in one of these fashions, suggesting that they did not feel uncomfortable while wearing the equipment. Second, I also considered that participants may experience a sense of self-consciousness from wearing the eye tracking equipment as they were aware that everything they looked at was being recorded. This is true, however, of any observational technique (e.g., think aloud, log file, and videotaping). Based on informal observations of participants' behaviours, I was confident that if there was any self-consciousness at the beginning of the session, it had faded over time. First, the large variability in the time spent with relevant information and the fact that some participants purposely attended to goal-irrelevant information suggested a lack of concern for having to stay on-task. Moreover, a couple of participants' data had to be excluded from the analyses because they closed their eyes for extended periods of time (possibly falling asleep for a moment) during the Internet search. Finally, I informally asked a group of participants whether or not their search behaviours were characteristic of how they would search for information outside of the lab. Besides being required to search for a longer period of time, all respondents indicated that the strategies and behaviours they used were fairly characteristic of their Internet searches.

Another strength of the current study was that participants were able to search the Internet without any restrictions, increasing the ecological validity of the task. This is a relatively novel technique within the literature. Learners have been commonly asked to navigate within closed hypermedia programs (e.g., Encarta) or were limited to particular Internet websites. The findings of the current study suggest that learners may navigate closed and open hypermedia environments in a different manner. This warrants further investigation into how the learning environment may impact on self-regulated learning at both the behavioural and cognitive level.

Future Research

The current study has provided a base for future research in three general areas. First, the findings indicate that time spent with relevant information is a major determinant of achievement among novices. To be able to develop appropriate supports, further research is necessary to more fully understand why some learners were more successful attending to relevant information when navigating the Internet. Although learners indicated little difficulty finding relevant information, it is unclear whether the challenge for some individuals was a function of an inability to separate relevant and irrelevant information or distraction. One may wish to consider environmental factors and their effect on Internet navigations. More specifically, what role does the environment play in learners search for and attention to goal-relevant information? How do learners respond behaviourally when faced with little relevant information or when they employ an inefficient strategy? On the other hand, an important finding of the current study was that a greater frequency of increases in mental effort was related to achievement by facilitating time spent with relevant information. Follow-up research which investigates mechanisms involved in the relation between mental effort and time spent with relevant information would contribute to an understanding of how cognitive processes facilitate on-task behaviours.

Second, future research may also examine the interaction of task and self-regulated learning characteristics for success. For example, although typically adopting an intrinsic goal orientation is beneficial for extensive tasks such as academic exams, this motivational component may result in off-task behaviour during quick assignments. Thus, in cases where learners conduct fast searches for information, it may be beneficial to provide learners with some form of scaffolding. Finally, the current study gives rise to an awareness of the generalizability of the findings, particularly regarding open vs. closed hypermedia environments and across different age groups.

Conclusion

Compared to traditional learning sources, the Internet is typically viewed as offering advantages to the learner. For example, individuals can control their own learning and access a vast amount of information at any time and from almost anywhere. As a result, the Internet has become a prevalent resource for information among high school and undergraduate students. Overall, adult novices benefited from a short period of time with the Internet. Upon closer examination however, it was clear that some novices exhibited difficulties learning, primarily due to a lack of time spent with relevant information. This has implications for models of learning from hypermedia, such that novices' difficulties when using hypermedia resources surface primarily with the selection of information. In addition, the findings indicate that under the task conditions, learners who reported lower levels of typically adopting an intrinsic goal orientation and greater frequency of increases in mental effort were more capable of attending to relevant information. Learners who reported regulating their effort during academic tasks to a lesser extent were observed as having a greater frequency of sudden increases in mental effort while navigating the Internet. Therefore, when learners do not have a rich knowledge base and are put in control of their own learning, there is a group of learners who may need to be supported. To be able to maximize learning from the Internet, however, a deeper understanding of the relation between cognitive processes and Internet navigations is necessary.

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Appendix A: Ethics clearance

DATE: September 11, 2007

FROM: Michelle McGinn, Chair
Research Ethics Board (REB)

TO: Teena Willoughby, Child and Youth Studies
Malinda DESJARLAIS
Crystal Paolone

FILE: 07-049 DESJARLAIS

TITLE: Individual Differences in Navigating the Internet when Domain Knowledge is Low

The Brock University Research Ethics Board has reviewed the above research proposal.

DECISION: Accepted as Clarified.

This project has received ethics clearance for the period of September 11, 2007 to April 30, 2008 subject to full REB ratification at the Research Ethics Board's next scheduled meeting. The clearance period may be extended upon request. ***The study may now proceed.***

Please note that the Research Ethics Board (REB) requires that you adhere to the protocol as last reviewed and cleared by the REB. During the course of research no deviations from, or changes to, the protocol, recruitment, or consent form may be initiated without prior written clearance from the REB. The Board must provide clearance for any modifications before they can be implemented. If you wish to modify your research project, please refer to http://www.brocku.ca/researchservices/forms to complete the appropriate form Revision or Modification to an Ongoing Application.

Adverse or unexpected events must be reported to the REB as soon as possible with an indication of how these events affect, in the view of the Principal Investigator, the safety of the participants and the continuation of the protocol.

If research participants are in the care of a health facility, at a school, or other institution or community organization, it is the responsibility of the Principal Investigator to ensure that the ethical guidelines and clearance of those facilities or institutions are obtained and filed with the REB prior to the initiation of any research protocols.

The Tri-Council Policy Statement requires that ongoing research be monitored. A Final Report is required for all projects upon completion of the project. Researchers with projects lasting more than one year are required to submit a Continuing Review Report annually. The Office of Research Services will contact you when this form *Continuing Review/Final Report* is required.

Please quote your REB file number on all future correspondence.

MM/bb

Brenda Brewster, Research Ethics Assistant
Office of Research Ethics, MC D250A
Brock University
Office of Research Services
500 Glenridge Avenue
St. Catharines, Ontario, Canada L2S 3A1
phone: (905)688-5550, ext. 3035 fax: (905)688-0748
email: reb@brocku.ca
http://www.brocku.ca/researchservices/ethics/humanethics/

Appendix B: Achievement Test (with Answers)

True or False

For each of the 5 statements, indicate whether the statement is True or False by circling your response. Also, please indicate how certain you are that your answer is correct by placing a check mark in the appropriate box beside each statement.

True or False?				How certain are you the answer is correct?		
				it's a guess	somewhat certain	very certain
1	**True**	False	Rotation of the earth causes the tropical cyclone to spin			
2	True	**False**	Tropical cyclones can start spontaneously			
3	True	**False**	Cyclones are based on a negative feedback system			
4	**True**	False	A storm is not classified as a tropical cyclone until its wind speed reaches over 100km/hr			
5	**True**	False	A topical cyclone gets its energy from condensation			

Multiple Choice:

Choose the best answer from the options provided. Also, for each multiple choice question please indicate how certain you are that your answer is correct.

1. Can a tropical cyclone easily form on the equator?
   a. Yes, because the temperature is ideal for the necessary evaporation to occur
   b. Yes, because the curving motion of wind caused by the Earth's rotation only occurs near the equator
   c. No, because the equator has a weak Coriolis force
   d. No, because only high pressure systems manifest near the equator

Circle your level of confidence that your answer for question 1 is correct:

it's a guess	somewhat certain	very certain

2 Why is it necessary to have high humidity for a tropical cyclone to form?
a. because humidity directly manifests the necessary high pressure system at the ocean's surface
b. humidity is not necessary for formation, rather it is a byproduct of the thunderstorms
c. because dry air sucks up moisture needed to power the cyclone
d. because humidity provides energy for the negative feedback loop

Circle your level of confidence that your answer for question 2 is correct:

it's a guess	somewhat certain	very certain

3. As the storm's altitude increase, the air cools causing _______________, which draws in ___________.

a. circulating spirals, heavy precipitation
b. increases in pressure, less air
c. the eye to become exposed, more air to rise upward
d. more water vapor to condense and release its heat, more air to rise upward

Circle your level of confidence that your answer for question 3 is correct:

it's a guess	somewhat certain	very certain

4. Which of the following is not a phase of tropical cyclone formation?
    a. as the cycle continues, surface pressure at the centre gradually rises
    b. atmospheric gases expand causing air inside to become less dense
    c. water vapor within the storm condense into water droplets
    d. increasing pressure pushes mass of clouds outward from centre

Circle your level of confidence that your answer for question 4 is correct:

it's a guess	somewhat certain	very certain

5. Which of the following illustrations is a correct representation of a tropical cyclone? Circle the Illustration name corresponding to your answer.

Illustration A:

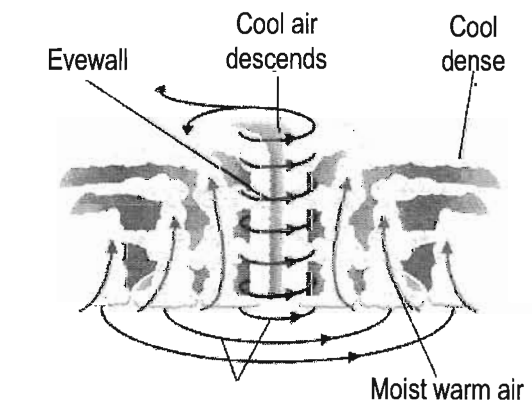


Illustration B:

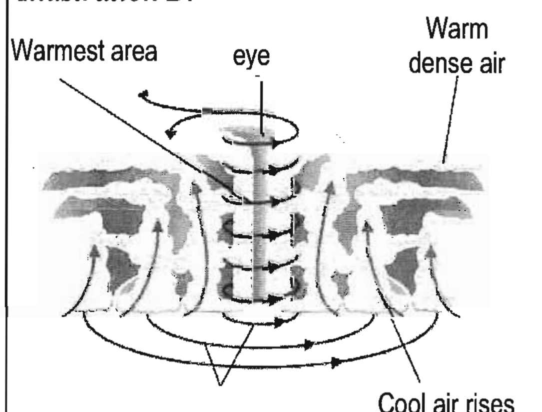


Illustration C:

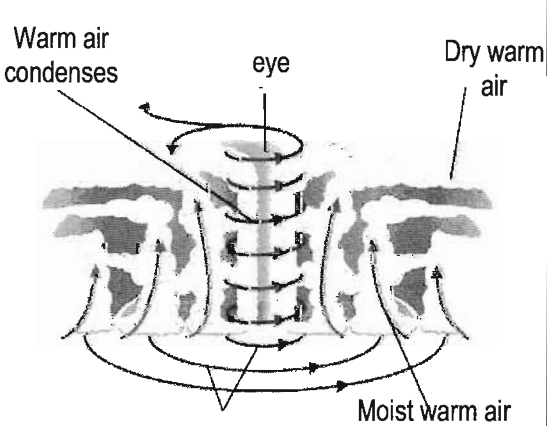
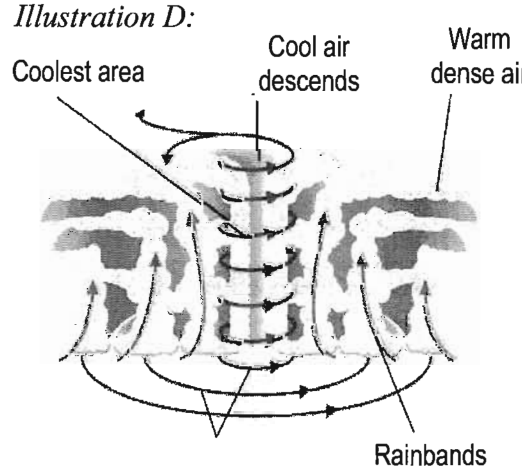


Illustration D:



Circle your level of confidence that your answer for question 5 is correct:

it's a guess	somewhat certain	very certain

Select All The Answers that Apply

Please indicate which of the listed answers are correct. For each answer, you are given the option of Yes or No. If the answer is correct then circle *Yes*. If the answer is incorrect then circle *No*. Do this for each answer provided. You will also be asked to rate your level of certainty that your answer is correct.

Is this considered favorable precursor conditions required for a tropical cyclone to form?

			How certain are you the answer is correct?		
			it's a guess	somewhat certain	very certain
Yes		low pressure centre			
Yes		Coriolis effect			
	No	surface winds diverge			
Yes		thunderstorms			
	No	high wind shear			
Yes		high humidity			
Yes		low wind shear			
Yes		warm ocean temperature			
	No	increasing surface pressure			
	No	cool ocean temperature			

Put the Following in Order

1. Put the following in order to illustrate the initial steps in how tropical cyclones form. Place a number 1 beside the first action, and continue until number 4 which will represent the final action.

4	Warm, moist air rises far above the ocean surface
3	Disturbance begins to rotate around an area of low pressure
1	Surface winds converge to create instabilities in the atmosphere
2	Cluster of small thunderstorms forms over the tropics

Circle your level of confidence that your answer is correct:	it's a guess	somewhat certain	very certain

2. The following are a continuation of the steps presented in the previous question. Continue to put the following statements in order to illustrate how tropical cyclones form. Place a number 5 beside the first action in this sequence, and continue until number 8 which will represent the final action.

5	Water vapor condenses into water droplets, releasing latent heat
7	The storm takes on characteristics of rotating spirals
6	Cool air is drawn down through the centre
8	The eye develops

Circle your level of confidence that your answer is correct:	it's a guess	somewhat certain	very certain

Appendix C: Demographic questionnaire

The following questions ask about demographic information, in addition to your Internet experience, knowledge and motivation.

Sex: O Male O Female Age: _______

Program/major: ___________________________________

A. How would you rate your *level of knowledge* for searching the Internet?

O	O	O	O	O
very low	somewhat low	moderate	somewhat high	very high

B. Approximately how long have you been accessing the Internet to search for information?

_______ years AND/OR _______ months

C. On an average day, how many hours do you spend on the Internet searching for information?

O	O	O	O	O	O
Less than 1 hour	1-2 hrs	2-3 hrs	3-4 hrs	4-5 hrs	More than 5 hours

D. How would you rate your level of motivation to search for information on the Internet?

O	O	O	O	O
very low	somewhat low	moderate	somewhat high	very high

E. On a scale from 1 to 9, how would you rate your level of knowledge regarding meteorology (weather patterns) in general?

1	2	3	4	5	6	7	8	9
very, very low				moderate				very, very high

F. On a scale from 1 to 9, how would you rate your level of knowledge regarding how tropical cyclones form?

1	2	3	4	5	6	7	8	9
very, very low				moderate				very, very high

G. How would you rate your level of motivation to learn about how tropical cyclones form?

O	O	O	O	O
very low	somewhat low	moderate	somewhat high	very high

Appendix D: Motivated Strategies Learning Questionnaire (MSLQ)

Motivated Strategies for Learning Questionnaire

Please reflect on your learning experiences across your courses. On a scale from 1 to 7, indicate (by circling the number) how true each statement is of you.

1 = Not at all true of me
7 = Very true of me

1. In my classes, I prefer course material that really challenges me so I can learn new things.	1	2	3	4	5	6	7
2. If I study in appropriate ways, then I will be able to learn the material in my classes.	1	2	3	4	5	6	7
3. When I take a test I usually think about how poorly I am doing compared with other students.	1	2	3	4	5	6	7
4. I think that I will be able to use what I learn in a typical course in other courses.	1	2	3	4	5	6	7
5. I believe I will receive an excellent grade in my courses.	1	2	3	4	5	6	7
6. I'm certain that I can understand the most difficult material presented in the readings in my courses.	1	2	3	4	5	6	7
7. Getting a good grade in my classes is the most satisfying thing for me right now.	1	2	3	4	5	6	7
8. When I take a test I think about items on other parts of the test I can't answer.	1	2	3	4	5	6	7
9. It is my own fault if I don't learn the material in my courses.	1	2	3	4	5	6	7
10. It is important for me to learn the course material in my courses.	1	2	3	4	5	6	7
11. The most important thing for me right now is improving my overall grade point average, so my main concern in my classes is getting good grades.	1	2	3	4	5	6	7
12. I'm confident I can learn the basic concepts taught in my courses.	1	2	3	4	5	6	7
13. If I can, I want to get better grades in my classes than most of the other students.	1	2	3	4	5	6	7
14. When I take tests I think of the consequences of failing.	1	2	3	4	5	6	7
15. I'm confident I can understand the most complex material presented by the instructor in my courses.	1	2	3	4	5	6	7
16. In my classes, I prefer course material that arouses my curiosity, even if it is difficult to learn.	1	2	3	4	5	6	7
17. I am very interested in the content area of my courses.	1	2	3	4	5	6	7
18. If I try hard enough, then I will understand the course material.	1	2	3	4	5	6	7
19. I have an uneasy, upset feeling when I take an exam.	1	2	3	4	5	6	7
20. I'm confident I can do an excellent job on the assignments and tests in my courses.	1	2	3	4	5	6	7

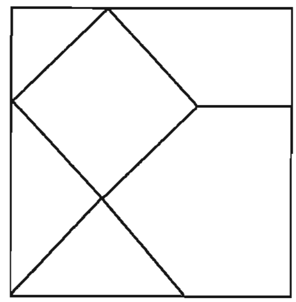
21. I expect to do well in my classes.	1	2	3	4	5	6	7
22. The most satisfying thing for me in my courses is trying to understand the content as thoroughly as possible.	1	2	3	4	5	6	7
23. I think the course material in my classes is useful for me to learn.	1	2	3	4	5	6	7
24. When I have the opportunity in my classes, I choose cources assignments that I can learn from even if they don't guarantee a good grade.	1	2	3	4	5	6	7
25. If I don't understand the course material, it is because I didn't try hard enough.	1	2	3	4	5	6	7
26. I like the subject matter of my courses.	1	2	3	4	5	6	7
27. Understanding the subject matter of my courses is very important to me.	1	2	3	4	5	6	7
28. I feel my heart beating fast when I take an exam.	1	2	3	4	5	6	7
29. I'm certain I can master the skills being taught in my classes.	1	2	3	4	5	6	7
30. I want to do well in my classes because it is important to show my ability to my family, friends, employer, or others.	1	2	3	4	5	6	7
31. Considering the difficulty of my courses, the teachers, and my skills, I think I will do well in my classes.	1	2	3	4	5	6	7
32. When I study the reading for my courses, I outline the material to help me organize my thoughts.	1	2	3	4	5	6	7
33. During class time I often miss important points because I'm thinking of other things.	1	2	3	4	5	6	7
34. When studying for my courses, I often try to explain the material to a classmate or friend.	1	2	3	4	5	6	7
35. I usually study in a place where I can concentrate on my course work.	1	2	3	4	5	6	7
36. When reading for my courses, I make up questions to help focus my reading.	1	2	3	4	5	6	7
37. I often feel so lazy or bored when I study for my classes that I quit before I finish what I planned to do.	1	2	3	4	5	6	7
38. I often find myself questioning things I hear or read in my courses to decide if I find them convincing.	1	2	3	4	5	6	7
39. When I study for my classes, I practice saying the material to myself over and over.	1	2	3	4	5	6	7
40. Even if I have trouble learning the material in my classes, I try to do the work on my own, without help from anyone.	1	2	3	4	5	6	7
41. When I become confused about something I'm reading for my classes, I go back and try to figure it out.	1	2	3	4	5	6	7
42. When I study for my courses, I go through the readings and my class notes and try to find the most important ideas.	1	2	3	4	5	6	7
43. I make good use of my study time for my courses.	1	2	3	4	5	6	7

44. If course readings are difficult to understand, I change the way I read the material.	1	2	3	4	5	6	7
45. I try to work with other students from my class to complete the course assignments.	1	2	3	4	5	6	7
46. When studying for my courses, I read my class notes and the course readings over and over again.	1	2	3	4	5	6	7
47. When a theory, interpretation, or conclusion is presented in class or in the readings, I try to decide if there is good supporting evidence.	1	2	3	4	5	6	7
48. I work hard to do well in my classes even if I don't like what we are doing.	1	2	3	4	5	6	7
49. I make simple charts, diagrams, or tables to help me organize course materials.	1	2	3	4	5	6	7
50. When studying for my courses, I often set aside time to discuss course material with a group of students from the class.	1	2	3	4	5	6	7
51. I treat the course material as a starting point and try to develop my own ideas about it.	1	2	3	4	5	6	7
52. I find it hard to stick to a study schedule.	1	2	3	4	5	6	7
53. When I study for my classes, I pull together information from different sources, such as lectures, readings, and discussions.	1	2	3	4	5	6	7
54. Before I study new course material thoroughly, I often skim it to see how it is organized.	1	2	3	4	5	6	7
55. I ask myself questions to make sure I understand the material I have been studying in my classes.	1	2	3	4	5	6	7
56. I try to change the way I study in order to fit the course requirements and the instructor's teaching style.	1	2	3	4	5	6	7
57. I often find that I have been reading for my classes but don't know what it was all about.	1	2	3	4	5	6	7
58. I ask the instructor to clarify concepts I don't understand well.	1	2	3	4	5	6	7
59. I memorize key words to remind me of important concepts in my classes.	1	2	3	4	5	6	7
60. When course work is difficult, I either give up or only study the easy parts.	1	2	3	4	5	6	7
61. I try to think through a topic and decide what I am supposed to learn from it rather than just reading it over when studying for my courses.	1	2	3	4	5	6	7
62. I try to relate ideas in the subject to those in other courses whenever possible.	1	2	3	4	5	6	7
63. When I study for my courses, I go over my class notes and make an outline of important concepts.	1	2	3	4	5	6	7
64. When reading for my classes, I try to relate the material to what I already know.	1	2	3	4	5	6	7
65. I have a regular place set aside for studying.	1	2	3	4	5	6	7

66. I try to play around with ideas of my own related to what I am learning in my courses.	1	2	3	4	5	6	7
67. When I study for my courses, I write brief summaries of the main ideas from the readings and my class notes.	1	2	3	4	5	6	7
68. When I can't understand the material in my courses, I ask another student in the class for help.	1	2	3	4	5	6	7
69. I try to understand the material in my classes by making connections between the readings and the concepts from lecture.	1	2	3	4	5	6	7
70. I make sure that I keep up with the weekly readings and assignments for my courses.	1	2	3	4	5	6	7
71. Whenever I read or hear an assertion or conclusion in my classes, I think about possible alternatives.	1	2	3	4	5	6	7
72. I make lists of important items for my courses and memorize the lists.	1	2	3	4	5	6	7
73. I attend my classes regularly.	1	2	3	4	5	6	7
74. Even when course materials are dull and uninteresting, I manage to keep working until I finish.	1	2	3	4	5	6	7
75. I try to identify students in my classes whom I can ask for help if necessary.	1	2	3	4	5	6	7
76. When studying for my courses I try to determine which concepts I don't understand well.	1	2	3	4	5	6	7
77. I often find that I don't spend very much time on my courses because of other activities.	1	2	3	4	5	6	7
78. When I study for my courses, I set goals for myself in order to direct my activities in each study period.	1	2	3	4	5	6	7
79. If I get confused taking notes in class, I make sure I sort it out afterwards.	1	2	3	4	5	6	7
80. I rarely find time to review my notes or readings before an exam.	1	2	3	4	5	6	7
81. I try to apply ideas from course readings in other class activities such as lecture and discussion.	1	2	3	4	5	6	7

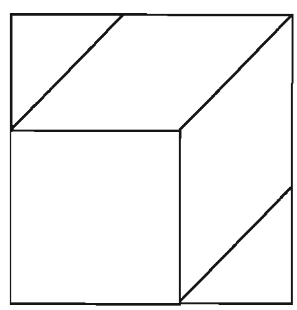
Appendix E: Group Embedded Figures Test (GEFT) Example

3.



Find Simple Form "D"

4.



Find Simple Form "E"

Appendix F: Attentional Control Scale (ACS)

Please fill in the circle that best describes you for each of the following questions.

	Never or almost never	Sometimes	Often	Always or almost always
1. It's very hard for me to concentrate on a difficult task when there are noises around.	....O....	....O....	....O....	....O....
2. When I need to concentrate and solve a problem, I have trouble focusing my attention.	....O....	....O....	....O....	....O....
3. When I am working hard on something, I still get distracted by events around me.	....O....	....O....	....O....	....O....
4. My concentration is good even if there is music in the room around me.	....O....	....O....	....O....	....O....
5. When concentrating, I can focus my attention so that I become unaware of what's going on in the room around me.	....O....	....O....	....O....	....O....
6. When I am reading or studying, I am easily distracted if there are people talking in the same room.	....O....	....O....	....O....	....O....
7. When trying to focus my attention on something, I have difficulty blocking out distracting thoughts.	....O....	....O....	....O....	....O....
8. I have a hard time concentrating when I'm excited about something.	....O....	....O....	....O....	....O....
9. When concentrating I ignore feelings of hunger or thirst.	....O....	....O....	....O....	....O....
10. I can quickly switch from one task to another.	....O....	....O....	....O....	....O....
11. It takes me a while to get really involved in a new task.	....O....	....O....	....O....	....O....
12. It is difficult for me to coordinate my attention between the listening and writing required when taking notes during lectures.	....O....	....O....	....O....	....O....

13. I can become interested in a new topic very quickly when I need to.	....O....	....O....	....O....	....O....
14. It is easy for me to read or write while I'm also talking on the phone.	....O....	....O....	....O....	....O....
15. I have trouble carrying on two conversations at once.	....O....	....O....	....O....	....O....
16. I have a hard time coming up with new ideas quickly.	....O....	....O....	....O....	....O....
17. After being interrupted or distracted, I can easily shift my attention back to what I was doing before.	....O....	....O....	....O....	....O....
18. When a distracting thought comes to mind, it is easy for me to shift my attention away from it.	....O....	....O....	....O....	....O....
19. It is easy for me to alternate between two different tasks.	....O....	....O....	....O....	....O....
20. It is hard for me to break from one way of thinking about something and look at it from another point of view.	....O....	....O....	....O....	....O....

Appendix G: Nelson-Denny Reading Test Sample

COMPREHENSION TEST

Thespis was supposed to have been the first poet who stepped out of the chorus and devised a dialogue with its members to make his poem more vivid. He was an Icarian, and his first official performance is supposed to have taken place in 534 B.C. The fashion he set quickly moved to Athens.

Meanwhile a boy had been born who was to make a new thing of all tragedy. His name was Aeschylus.

He was born in 525 B.C., at Eleusis, a little town twelve miles from Athens. At the age of twenty-six, he had written a tragedy, and in 484 B.C., when he was forty-one, he won the tragedy prize. He was to win it twelve times more before he died.

Now, in writing tragedy, Aeschylus did two things that greatly changed the celebrations. Up to this time, there had not been what we know as plays. There were only the single actor and the chorus. Nothing much could happen in the orchestra while this was the custom. The actor could talk to the chorus, or he could recite his poem.

But Aeschylus put on two actors, and was then able to make his poem an imitation of the actual happenings of the legends the Greeks knew. One character could tell the story by talking to another, messengers could bring news. Kings could quarrel, prophets could warn foolish warriors. With the two actors and the chorus it was possible to make almost any story live again in speech and action before men's very eyes.

The second gift of Aeschylus grew out of the first. With the new form of making a poem, he brought great skill as a poet. As this was fused with the acting out of the legends he retold, a new kind of poetry was born. In epic poetry, the listeners could hear about their heroes. In this new tragedy, they saw and listened to them.

The great Prometheus, chained in torment by Zeus because he had stolen fire from heaven for men, suffered his agony before their eyes and foretold to them the triumph he must win. Agamemnon, proud and sinful, came back from Troy in triumph to be murdered by his own wife.

These legends were serious stories, most of them unhappy or terrible. The Athenians, watching one of them lived out again, saw a warning against pride or cruelty or folly, or perhaps felt a likeness to misfortunes which they themselves had actually suffered. But pain was softened by the sound of flutes and lyre, the rhythm of dancers, the majesty of noble words. So there was a relief, a cleansing of the spirit, in watching this dream-like beauty and sorrow. As there is something healing in the shedding of tears for a loved one who has died, so in this new poetry the Athenians in an exalted manner found a relief from their fear of misfortune and their memories of pain in the sobbing "Woe! Woe!" of the chorus.

Of the more than ninety plays Aeschylus is said to have written before he died at the age of seventy-one, we have only seven. Probably the greatest and most moving of his works is the terrible story, told in three plays, of Agamemnon's murder by Clytemnestra and Clytemnestra's death at the hands of her own son, Orestes. One distinguished modern poet has called it "the greatest spiritual work of the human mind." *The Persians*, another drama, is splendid in a different way. Cast in the form of a tragedy, it tells of the defeat of Xerxes and the Persian fleet at Salamis, 480 B.C. The scene is the Persian court, the heroine is Atossa, the Persian queen. Yet, though her sorrow is told with understanding and sympathy, the play was a celebration for the Athenians as well as a representation of grief.

1. *Aeschylus was born in*
   A. Athens.
   B. Troy.
   C. Delphi.
   D. Eleusis.
   E. Aeolis.

2. *Aeschylus made how many changes?*
   A. One
   B. Two
   C. Three
   D. Four
   E. None

3. *The Persian fleet was defeated at*
   A. Athens.
   B. Salonika.
   C. Marathon.
   D. Ithaca.
   E. Salamis.

4. *During the period described in the selection, poets were apparently considered*
   A. quite important.
   B. somewhat important.
   C. not particularly important.
   D. somewhat unimportant.
   E. quite unimportant.

5. *The greatest spiritual work of the human mind was said to be the story of*
   A. Prometheus.
   B. the Persians.
   C. Agamemnon.
   D. Ulysses.
   E. Jason.

6. *The chief advantage of the tragedies of Aeschylus was*
   A. the visible interplay of characters.
   B. The augmented power of the chorus.
   C. their majestic style.
   D. their heroic subject matter.
   E. their current relevance.

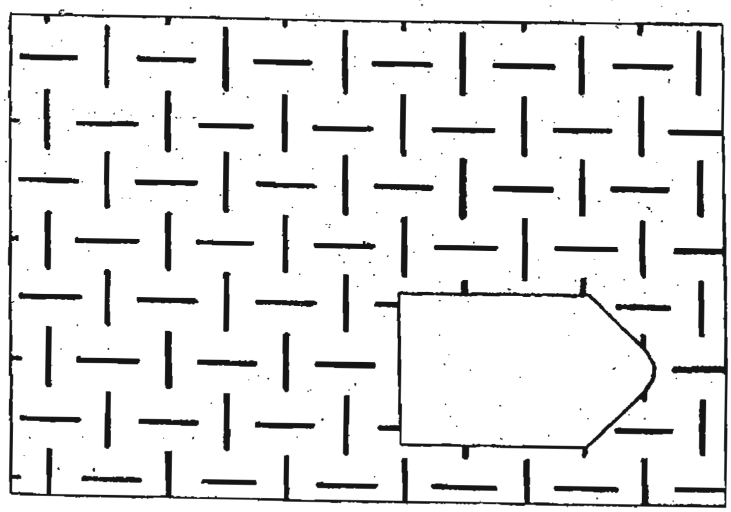
7. *Tragedies were apparently liked primarily because*
   A. they were serious commentaries on life.
   B. they made life more beautiful.
   C. they provided solutions for common problems.
   D. they were noble.
   E. they cleansed the spirits of the watchers.

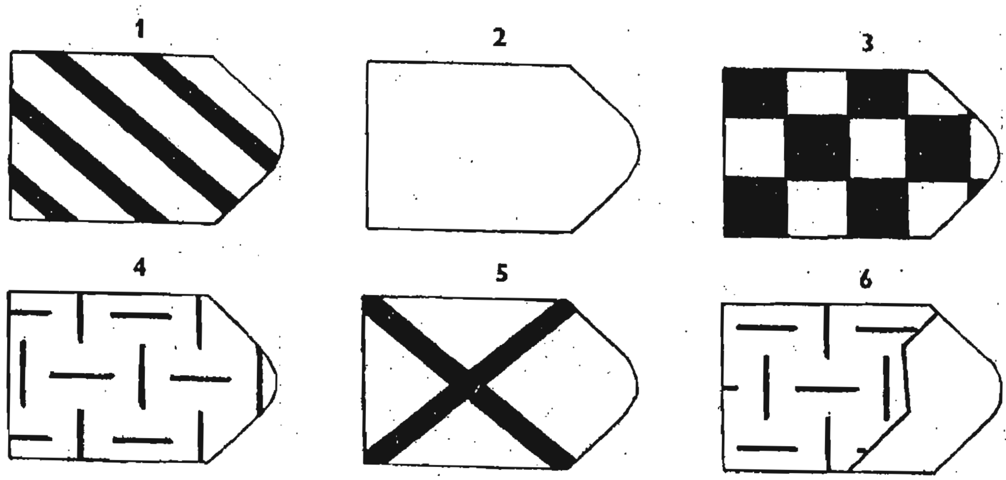
8. *You would infer that our word thespian describes*
   A. a poet.
   B. a playwright.
   C. an actor.
   D. a musician.
   E. an Icarian.

Appendix H: Raven's Progressive Matrices Example

SET A

A.1





Appendix I: List of Unique Webpages

No.	Webpage URL	Tally	Notes	Relevancy
1	http://ams.confex.com/ams/Annual2005/techprogram/paper_87148.htm	4		R
2	http://answers.yahoo.com/question/index?qid=20071014040437AA7wdTC&show=7	1		R
3	http://clearlyexplained.com/nature/earth/disasters/cyclones.html	8		R
4	http://earthobservatory.nasa.gov/Library/Hurricanes/	1		R
5	http://earthsci.org/flood/J_Flood04/cyclone/cyclone.html	6		R
6	http://earthsci.org/Flooding/unit1/u1-05-01.html	14		R
7	http://earthsci.org/Flooding/unit1/u1-05-01a.html	4	*image*	R
8	http://earthsci.org/Flooding/unit1/u1-05-01b.html	4	*image*	R
9	http://earthsci.org/Flooding/unit1/u1-05-01c.html	1	*image*	R
10	http://earthsci.org/Flooding/unit1/u1-05-02.html	4		R
11	http://earthsci.org/Flooding/unit1/u1-08-00.html	1		R
12	http://earthsci.org/Flooding/unit1/u1-08-01.html	2		R
13	http://earthsci.org/processes/weather/cyclone/cyclone.html	1		R
14	http://en.wikipedia.org/wiki/Cyclone	2		R
15	http://en.wikipedia.org/wiki/Hurricane	17		R
16	http://en.wikipedia.org/wiki/Tropical_cyclogenesis	7		R
17	http://en.wikipedia.org/wiki/Tropical_cyclone	48		R
18	http://en.wikipedia.org/wiki/Tropical_cyclones	2		R
19	http://en.wikipedia.org/wiki/Tropical_storm	1		R
20	http://encarta.msn.com/encyclopedia_761565992/Hurricane.html	2		R
21	http://faqs.cs.uu.nl/na-dir/meteorology/storms-faq/part1.html	1		R
22	http://images.google.ca/imgres?imgurl=http://www.lnnu.edu.cn/dandu/jxjy/e2/files/dingpu/files/Formation%2520of%2520a%2520Hurricane.files/T268458A.gif&imgrefurl=http://www.lnnu.edu.cn/dandu/jxjy/e2/files/dingpu/files/Formation%2520of%2520a%2520Hu	1		R
23	http://kids.earth.nasa.gov/archive/hurricane/	1		R
24	http://kids.earth.nasa.gov/archive/hurricane/creation.html	1		R
25	http://ksks.essortment.com/hurricaneformat_rmem.htm	1		R
26	http://library.thinkquest.org/03oct/01027/tropicalcyclones.html	24		R
27	http://library.thinkquest.org/10136/cyclones/cycltq.htm	2		R
28	http://library.thinkquest.org/C003157/air/tropical.htm	2		R
29	http://observe.arc.nasa.gov/nasa/earth/hurricane/form.html	1		R
30	http://people.cas.sc.edu/carbone/modules/mods4car/tropcycl/pages/formation.html	8		R
31	http://physics.suite101.com/article.cfm/tropical_cyclone_formation	2		R
32	http://physics.suite10com/article.cfm/tropical_cyclone_formation	3		R
33	http://polish.wunderground.com/blog/Alec/comment.html	1		R
34	http://science.howstuffworks.com/hurricane.htm	1		R
35	http://science.howstuffworks.com/hurricane1.htm	1		R
36	http://science.howstuffworks.com/hurricane2.htm	1		R

37	http://scifiles.larc.nasa.gov/kids/Problem_Board/problems/weather/hurricanebasics.swf	1		R
38	http://simple.wikipedia.org/wiki/Hurricane	1		R
39	http://simple.wikipedia.org/wiki/Tropical_cyclone	6		R
40	http://snowball.millersville.edu/~adecaria/ESCI344/esci344_lesson10_TC_structure.html	1		R
41	http://spaceplace.nasa.gov/en/kids/goes/hurricanes/	2		R
42	http://spaceplace.nasa.gov/en/kids/goes/hurricanes/index.shtml	3		R
43	http://stason.org/TULARC/science-engineering/storm-hurricane-typhoons/10-How-do-tropical-cyclones-form.html	12		R
44	http://web.mit.edu/1000/www/m2010/finalwebsite/background/hurricanes/images/hurricaneformation.jpg	1	*image*	R
45	http://web.mit.edu/12.000/www/m2010/finalwebsite/background/hurricanes/hurricanewhatis.html	1		R
46	http://web.mit.edu/12.000/www/m2010/teams/neworleans1/hurricane%20science_files/image003.jpg	1		R
47	http://ww2010.atmos.uiuc.edu/(Gh)/guides/mtr/cyc/upa/jet.rxml	1		R
48	http://ww2010.atmos.uiuc.edu/(Gh)/guides/mtr/hurr/grow/home.rxml	1		R
49	http://ww2010.atmos.uiuc.edu/(Gh)/guides/mtr/hurr/home.rxml	2		R
50	http://ww2010.atmos.uiuc.edu/(Gh)/guides/mtr/hyd/cond/cycl.rxml	1		R
51	http://ww2010.atmos.uiuc.edu/(Gh)/wwhlpr/condensation.rxml?hret=/guides/mtr/hyd/cond/cycl.rxml	1		R
52	http://ww2010.atmos.uiuc.edu/(Gh)/wwhlpr/low_pressure_center.rxml?hret=/guides/mtr/hyd/cond/cycl.rxml	1		R
53	http://www.aerospaceweb.org/question/atmosphere/q0242.shtml	8		R
54	http://www.aims.gov.au/pages/reflib/cyclones/pages/cs-04.html	4		R
55	http://www.answers.com/topic/tropical-cyclone?cat=health	1		R
56	http://www.aoml.noaa.gov/hrd/tcfaq/A15.html	25		R
57	http://www.aoml.noaa.gov/hrd/tcfaq/A16.html	1		R
58	http://www.aoml.noaa.gov/hrd/tcfaq/formations.jpg	1	*image*	R
59	http://www.aoml.noaa.gov/hrd/tcfaq/G6.html	1		R
60	http://www.aoml.noaa.gov/hrd/tcfaq/L1.html	1		R
61	http://www.armageddononline.org/tropical_storm.php	2		R
62	http://www.atl.ec.gc.ca/weather/hurricane/hurricanes1a.html	32		R
63	http://www.atl.ec.gc.ca/weather/hurricane/hurricanes1d.html	2		R
64	http://www.barrierreefaustralia.com/cyclone/cyclonehtm	1		R
65	http://www.bom.gov.au/info/cyclone/	4		R
66	http://www.bom.gov.au/weather/cyclone/about/about-tropical-cyclones.shtml	2		R
67	http://www.bom.gov.au/weather/wa/cyclone/about/faq/faq_char_2.shtml	14		R
68	http://www.bom.gov.au/weather/wa/cyclone/about/faq/faq_def_6.shtml	1		R
69	http://www.britannica.com/eb/art-75357?articleTypeId=1	1		R
70	http://www.britannica.com/eb/art-75359/Wrecked-houseboats-and-bent-palm-trees-in-Key-West-Florida?articleTypeId=1	1	*image*	R
71	http://www.britannica.com/eb/article-247918/tropical-cyclone	2		R
72	http://www.britannica.com/eb/article-247920/tropical-cyclone	3		R

73	http://www.britannica.com/eb/article-247921/tropical-cyclone	3		R
74	http://www.britannica.com/eb/article-67118/ocean	8		R
75	http://www.britannica.com/eb/article-67119/ocean	2		R
76	http://www.britannica.com/eb/article-9106251/tropical-cyclone	9		R
77	http://www.cbc.ca/news/background/forcesofnature/tropicalstorms.html	1		R
78	http://www.channel4learning.com/support/programmenotes/netnotes/content/pdfs/planet_earth/ge_p3_a1w.pdf	1		R
79	http://www.cyclonerita.com/index.php?option=com_content&task=view&id=18&Itemid=9	1		R
80	http://www.enotes.com/earth-science/tropical-cyclone	2		R
81	http://www.faqs.org/faqs/meteorology/storms-faq/part1/	2		R
82	http://www.faqs.org/qa/qa-1582html	1		R
83	http://www.faqs.org/qa/qa-4253.html	25		R
84	http://www.geography.learnontheinternet.co.uk/gcse/tropical.html	1		R
85	http://www.geographypages.co.uk/tropcyc.htm	11		R
86	http://www.goldiproductions.com/.../hurricanes.html	1		R
87	http://www.greenpeace.org/canada/en/campaigns/climate-and-energy/threats/extreme-weather	1		R
88	http://www.guideto.com/hurricanes-cyclones/the-wrath-of-tropical-cyclones	1		R
89	http://www.howstuffworks.com/framed.htm?parent=hurricane.htm&url=http://kids.earth.nasa.gov/archive/hurricane/creation.html	1		R
90	http://www.hurricanezone.net/articles/tropical-cyclone-formation.html	10		R
91	http://www.kjc.gov.my/english/education/weather/tropicalcyc01.html	3		R
92	http://www.livescience.com/environment/hurricane_formation.html	1		R
93	http://www.mapsofworld.com/hurricane/how-tropical-cyclone-formed.html	4		R
94	http://www.mapsofworld.com/hurricane/mechanism-of-tropical-cyclone.jpg	1	*image*	R
95	http://www.mapsofworld.com/hurricane/mechanism-of-tropical-cyclone-formation.html	11		R
96	http://www.mapsofworld.com/referrals/weather/severe-weather-conditions/tropical-cyclone.html	2		R
97	http://www.math.montana.edu/~nmp/materials/ess/atmosphere/inter/activities/hurricane/form.html	1		R
98	http://www.meteo.fr/meteonet_en/decouvr/dossier/cyclone/cyc.htm	1		R
99	http://www.metoffice.gov.uk/corporate/pressoffice/hurricanes/index.html	1		R
100	http://www.metoffice.gov.uk/education/secondary/students/tropical_cyclones.html	1		R
101	http://www.nhc.noaa.gov/aboutgloss.shtml?text#TROPCYC	1		R
102	http://www.nhc.noaa.gov/HAW2/english/basics.shtml	1		R
103	http://www.nrlmry.navy.mil/~chu/chap3/se101.htm#sec1_1	1		R

104	http://www.ntlib.nt.gov.au/tracy/advanced/Met/Life_Cycle.html	22		R
105	http://www.oas.org/cdmp/document/forecast/forecast.htm	1		R
106	http://www.ohsep.louisiana.gov/factsheets/TropicalStrmStructre.htm	1		R
107	http://www.oobdoo.org/wiki/Tropical_Cyclone.htm	2		R
108	http://www.pagasa.dost.gov.ph/genmet/tropicalcyclone/tc_index.html	1		R
109	http://www.ritainfo.com/hurricane-diagram.gif	3	*image*	R
110	http://www.seafriends.org.nz/oceano/storms.htm	1		R
111	http://www.srh.noaa.gov/jetstream/tropics/tc.htm	9		R
112	http://www.srh.noaa.gov/jetstream/tropics/tc_structure.htm	4		R
113	http://www.srh.weather.gov/srh/jetstream/tropics/tc.htm	1		R
114	http://www.super70s.com/Super70s/Tech/Nature/Disasters/Hurricanes/About.asp	2		R
115	http://www.theweathernetwork.com/tropicalstorm/hurricane_glossary	1		R
116	http://www.usatoday.com/weather/whur7.htm	1		R
117	http://www.usatoday.com/weather/whur7.htm?loc=interstitialskip	1		R
118	http://www.weather.com/encyclopedia/tropical/forecast.html	2		R
119	http://www.weather.gov.hk/informtc/nature.htm	1		R
120	http://www.weatherquestions.com/What_causes_hurricanes.htm	1		R
121	http://www.weathersa.co.za/References/Cyclones.jsp	36		R
122	http://www.weatherwizkids.com/hurricane1.htm	1		R
123	http://www.windows.ucar.edu/tour/link=/earth/Atmosphere/hurricane/formation.html&edu=elem	1		R
124	http://www.windows.ucar.edu/tour/link=/earth/Atmosphere/hurricane/formation.html&edu=high	1		R
125	http://www.wunderground.com/blog/Alec/archive.html	1		R
126	http://www-das.uwyo.edu/~geerts/cwx/notes/chap13/trop_cyclogenesis.html	2		R
127	pdf: Tonga Meteorological Service – Ministry of Civil Aviation: TROPICAL CYCLONE INFORMATION	1		R
128	cimss.ssec.wisc.edu/cimss25th/presentations/huang.pdf	1		NR
129	ftp://ftp.coaps.fsu.edu/pub/eric/papers_html/Cherubin_et_al_0.pdf	1		NR
130	http://abyss.uoregon.edu/~js/glossary/coriolis_effect.html	1		NR
131	http://adsabs.harvard.edu/abs/1977JAtS...31007S	1		NR
132	http://ams.allenpress.com/perlserv/?request=get-abstract&doi=11175%2F1520-0469(1993)050%3C0285:TCF%3ECO%3B2	1		NR
133	http://arxiv.org/ftp/physics/papers/0601/0601050.pdf	1		NR
134	http://asp1.sbs.ohio-state.edu/tropicaltext.html	1	*pg not found*	NR
135	http://atlas.nrcan.gc.ca/site/english/maps/environment/naturalhazards/naturalhazards1999/majorhurricanes/hurricanes_stats_new.html	1		NR
136	http://au.answers.yahoo.com/answers2/frontend.php/question?qid=20071207192411AAOutda	1		NR
137	http://cache.eb.com/eb/image?id=7572&rendTypeId=4	1	*image*	NR
138	http://cimss.ssec.wisc.edu/tropic/tropic.html	6		NR

139	http://cimss.ssec.wisc.edu/tropic2/browsererror.html	1	*error*	NR
140	http://commons.wikimedia.org/wiki/Coriolis_effect	1		NR
141	http://dictionary.reference.com/browse/cyclogenesis	1		NR
142	http://dictionary.reference.com/browse/cyclone	1		NR
143	http://dictionary.reference.com/browse/tropical	1		NR
144	http://dictionary.reference.com/browse/tropical%20cyclone	1		NR
145	http://dictionary.reference.com/search?q=tropical cyclone	1		NR
146	http://earthsci.org/Flooding/unit1/u1-05-00.html	1		NR
147	http://earthsci.org/Flooding/unit1/u1-05-03.html	2		NR
148	http://earthsci.org/Flooding/unit1/u1-08-02.html	2		NR
149	http://earthsci.org/Flooding/unit1/u1-08-03.html	1		NR
150	http://earthsci.org/Flooding/unit1/u1-08-04.html	1		NR
151	http://earthsci.org/Flooding/unit2/index.html	1		NR
152	http://en.allexperts.com/q/Meteorology-Weather-668/coreolis-effect.htm	1		NR
153	http://en.mimi.hu/meteorology/convergence.html	1		NR
154	http://en.mimi.hu/meteorology/divergence.html	1		NR
155	http://en.wikipedia.org/w/index.php?title=Tropical_cyclone&action=history	1	*history tab*	NR
156	http://en.wikipedia.org/wiki/Air_mass#Classification	1		NR
157	http://en.wikipedia.org/wiki/Atmospheric_circulation	1		NR
158	http://en.wikipedia.org/wiki/Barotropic_cyclone	1		NR
159	http://en.wikipedia.org/wiki/Beaufort_scale	1		NR
160	http://en.wikipedia.org/wiki/Category:Tropical_cyclones	1		NR
161	http://en.wikipedia.org/wiki/Category:Types_of_cyclone	1		NR
162	http://en.wikipedia.org/wiki/Condensation	2		NR
163	http://en.wikipedia.org/wiki/Coriolis_effect	11		NR
164	http://en.wikipedia.org/wiki/Coriolis_force	2		NR
165	http://en.wikipedia.org/wiki/Effects_of_tropical_cyclones	1		NR
166	http://en.wikipedia.org/wiki/Eye_%28cyclone%29#Stadium_effect	5		NR
167	http://en.wikipedia.org/wiki/Heat_of_condensation	6		NR
168	http://en.wikipedia.org/wiki/Hurricane_Andrew	1		NR
169	http://en.wikipedia.org/wiki/Hurricane_Katrina	1		NR
170	http://en.wikipedia.org/wiki/Image:Atlantic_hurricane_graphic.gif	2	*image*	NR
171	http://en.wikipedia.org/wiki/Image:Cyclone_Catarina_from_the_ISS_on_March_26_2004.JPG	1	*image*	NR
172	http://en.wikipedia.org/wiki/Image:Cyclone_Monica.gif	1	*image*	NR
173	http://en.wikipedia.org/wiki/Image:Earth_Atmosphere.svg	1	*image*	NR
174	http://en.wikipedia.org/wiki/Image:Global_tropical_cyclone_tracks-edit.jpg	2	*image*	NR
175	http://en.wikipedia.org/wiki/Image:Global_tropical_cyclone_tracks-edit2.jpg	2	*image*	NR
176	http://en.wikipedia.org/wiki/Image:Hurricane_Kate_%282003%29-_Good_pic.jpg	1	*image*	NR
177	http://en.wikipedia.org/wiki/Image:Hurricane_katrina_damage_gulfport_mississippi.jpg	2	*image*	NR
178	http://en.wikipedia.org/wiki/Image:Hurricane_profile.svg	2	*image*	NR

179	http://en.wikipedia.org/wiki/Image:Hurricane_structure_graphic.jpg	5	*image*	NR
180	http://en.wikipedia.org/wiki/Image:Ioke_2006_track.png	1	*image*	NR
181	http://en.wikipedia.org/wiki/Image:Isidore091902-p3sunset.jpg	1	*image*	NR
182	http://en.wikipedia.org/wiki/Latent_heat	1		NR
183	http://en.wikipedia.org/wiki/Latitudes	2		NR
184	http://en.wikipedia.org/wiki/Low_pressure_system	1		NR
185	http://en.wikipedia.org/wiki/Mesocyclone	1		NR
186	http://en.wikipedia.org/wiki/Mesoscale_Convective_Complex	1		NR
187	http://en.wikipedia.org/wiki/Nor%27easter	1		NR
188	http://en.wikipedia.org/wiki/Polar_cyclone	1		NR
189	http://en.wikipedia.org/wiki/Portal:Tropical_cyclones	1		NR
190	http://en.wikipedia.org/wiki/Positive_feedback_loop	1		NR
191	http://en.wikipedia.org/wiki/Rotating_frame_of_reference	1		NR
192	http://en.wikipedia.org/wiki/Storm_surge	2		NR
193	http://en.wikipedia.org/wiki/Subtropical_cyclone	2		NR
194	http://en.wikipedia.org/wiki/Subtropical_ridge	1		NR
195	http://en.wikipedia.org/wiki/Temperate	2		NR
196	http://en.wikipedia.org/wiki/Tropical_cyclone_naming	1		NR
197	http://en.wikipedia.org/wiki/Tropical_cyclone_observation	1		NR
198	http://en.wikipedia.org/wiki/Tropics	1		NR
199	http://en.wikipedia.org/wiki/Troposphere	3		NR
200	http://en.wikipedia.org/wiki/Wikipedia	1		NR
201	http://en.wikipedia.org/wiki/Wind_shear	5		NR
202	http://encarta.msn.com/encyclopedia_761588007/Tropical_Storm.html	1		NR
203	http://epirev.oxfordjournals.org/cgi/content/extract/27/1/21	1		NR
204	http://faqs.cs.uu.nl/na-dir/meteorology/storms-faq/part2.html	1		NR
205	http://hurricane.terrapin.com/	1		NR
206	http://hurricane.terrapin.com/CurrentSeason.html.en	1		NR
207	http://investing.reuters.co.uk/news/articleinvesting.aspx?type=allBreakingNews&storyID=2007-11-09T135134Z_01_L09459644_RTRIDST_0_AUSTRALIA-CYCLONES.XML	1		NR
208	http://kids.earth.nasa.gov/archive/hurricane/Fran.mov	1	*video*	NR
209	http://library.thinkquest.org/03oct/01027/index.htm	1		NR
210	http://library.thinkquest.org/J002321/Cyclone.htm	1		NR
211	http://maps.csc.noaa.gov/hurricanes/tropical.htm	1		NR
212	http://members.tripod.com/~Post_119_Gulfport_MS/tropical.html	1		NR
213	http://people.cas.sc.edu/carbone/modules/mods4car/tropcycl/pages/easterlywave.html	8		NR
214	http://people.cas.sc.edu/carbone/modules/mods4car/tropcycl/pages/easterlywave2.html	5		NR
215	http://people.cas.sc.edu/carbone/modules/mods4car/tropcycl/pages/energy_intro.html	1		NR
216	http://people.cas.sc.edu/carbone/modules/mods4car/tropcycl/pages/form_intro.html	11		NR
217	http://people.cas.sc.edu/carbone/modules/mods4car/tropcycl/pages/itcz.html	8		NR

218	http://people.cas.sc.edu/carbone/modules/mods4car/tropcycl/pages/itcz2.html	8		NR
219	http://people.cas.sc.edu/carbone/modules/mods4car/tropcycl/pages/struc_intro.html	6		NR
220	http://people.cas.sc.edu/carbone/modules/mods4car/tropcycl/pages/structure.html	5		NR
221	http://people.cas.sc.edu/carbone/modules/mods4car/tropcycl/pages/structure2.html	3		NR
222	http://people.cas.sc.edu/carbone/modules/mods4car/tropcycl/pages/structure3.html	3		NR
223	http://science.howstuffworks.com/hurricane3.htm	1		NR
224	http://simple.wikipedia.org/wiki/Cyclone	1		NR
225	http://spaceplace.nasa.gov/en/kids/goes/hurricanes/hurricane_katrina.shtml	1	*video*	NR
226	http://stason.org/TULARC/science-engineering/storm-hurricane-typhoons/11-Why-are-tropical-cyclones-named.html	2		NR
227	http://stason.org/TULARC/science-engineering/storm-hurricane-typhoons/12-What-are-the-tropical-cyclone-names-through-2001.html	1		NR
228	http://stason.org/TULARC/science-engineering/storm-hurricane-typhoons/21-Why-do-tropical-cyclones-winds-rotate-counter-clockwise.html	1		NR
229	http://teacher.scholastic.com/activities/wwatch/hurricanes/	1		NR
230	http://typhoon.atmos.colostate.edu/forecasts/	1		NR
231	http://vathena.arc.nasa.gov/curric/weather/storms/tropcyclone.html	3		NR
232	http://video.google.ca/videoplay?docid=-5398799391519807808&q=tropical+cyclones&total=43&start=0&num=10&so=0&type=search&plindex=1	1	*video*	NR
233	http://video.google.ca/videoplay?docid=-6291512596205139 7&q=tropical+cyclones&total=43&start=0&num=10&so=0&type=search&plindex=6	1	*video*	NR
234	http://weather.about.com/od/hurricanes/ss/hurricaneprep_htm	1		NR
235	http://web.ebscohost.com/ehost/detail?vid=1&hid=115&sid=30709f3c-5104-4f8a-84c8-20399d4fc43e%40sessionmgr102	1	*ebscohost database*	NR
236	http://web.ebscohost.com/ehost/pdf?vid=3&hid=22&sid=5a0aaced-8cb9-43a6-bddb-5eba68bf62e2%40sessionmgr2	1		NR
237	http://ww2010.atmos.uiuc.edu/(Gh)/guides/mtr/hurr/stages/home.rxml	2		NR
238	http://ww2010.atmos.uiuc.edu/(Gh)/guides/mtr/hurr/stages/td.rxml	1		NR
239	http://ww2010.atmos.uiuc.edu/(Gh)/guides/mtr/hurr/stages/ts.rxml	1		NR
240	http://ww2010.atmos.uiuc.edu/(Gh)/guides/mtr/hyd/home.rxml	1		NR
241	http://ww2010.atmos.uiuc.edu/(Gh)/wwhlpr/convergence.rxml?hret=/guides/mtr/hyd/cond/cycl.rxml	1		NR
242	http://ww2010.atmos.uiuc.edu/(Gh)/wwhlpr/front_hyd.rxml?hret=/guides/mtr/hyd/cond/cycl.rxml	1		NR
243	http://ww2010.atmos.uiuc.edu/(Gh)/wwhlpr/hurricane_eye.rxml?hret=/guides/mtr/hurr/stages/cane/home.rxml	1		NR

244	http://ww2010.atmos.uiuc.edu/(Gh)/wwhlpr/hurricane_tropdep.rxml?hret=/guides/mtr/hurr/stages/home.rxml	1		NR
245	http://www.aerospaceweb.org/question/atmosphere/hurricane/tropical-cyclone.jpg	1	*image*	NR
246	http://www.agu.org/pubs/crossref/2007/2007GL029977.shtml	1		NR
247	http://www.answers.com/topic/coriolis-effect?cat=technology	1		NR
248	http://www.aoml.noaa.gov/hrd/tcfaq/A1.html	6		NR
249	http://www.aoml.noaa.gov/hrd/tcfaq/A4.html	1		NR
250	http://www.aoml.noaa.gov/hrd/tcfaq/A5.html	3		NR
251	http://www.aoml.noaa.gov/hrd/tcfaq/B1.html	1		NR
252	http://www.aoml.noaa.gov/hrd/tcfaq/C1.html	2		NR
253	http://www.aoml.noaa.gov/hrd/tcfaq/E1.html	2		NR
254	http://www.aoml.noaa.gov/hrd/tcfaq/E14.html	1		NR
255	http://www.aoml.noaa.gov/hrd/tcfaq/F1.html	2		NR
256	http://www.aoml.noaa.gov/hrd/tcfaq/tcfaqA.html	2		NR
257	http://www.aoml.noaa.gov/hrd/tcfaq/tcfaqHED.html	13		NR
258	http://www.atl.ec.gc.ca/cgi-bin/redirect.pl?http://typhoon.atmos.colostate.edu/forecasts/	1	*links*	NR
259	http://www.atl.ec.gc.ca/weather/hurricane/hurricanes.html	4		NR
260	http://www.atl.ec.gc.ca/weather/hurricane/hurricanes1.html	2		NR
261	http://www.atl.ec.gc.ca/weather/hurricane/hurricanes1b.html	6		NR
262	http://www.atl.ec.gc.ca/weather/hurricane/hurricanes1c.html	5		NR
263	http://www.atl.ec.gc.ca/weather/hurricane/hurricanes1e.html	3		NR
264	http://www.atl.ec.gc.ca/weather/hurricane/hurricanes1f.html	2		NR
265	http://www.atl.ec.gc.ca/weather/hurricane/hurricanes7.html	1		NR
266	http://www.atl.ec.gc.ca/weather/hurricane/hurricanes7a.html	1		NR
267	http://www.atl.ec.gc.ca/weather/hurricane/hurricanes7b.html	2		NR
268	http://www.atl.ec.gc.ca/weather/hurricane/hurricanes9.html	17		NR
269	http://www.atl.ec.gc.ca/weather/hurricane/hurricanes9b.html	4	*image*	NR
270	http://www.atl.ec.gc.ca/weather/hurricane/hurricanes9f.html	1	*image*	NR
271	http://www.atl.ec.gc.ca/weather/hurricane/index_e.html	1	*links*	NR
272	http://www.atl.ec.gc.ca/weather/hurricane/links.html	1		NR
273	http://www.bom.gov.au/weather/cyclone/	1		NR
274	http://www.bom.gov.au/weather/wa/cyclone/about/faq/faq_char_1.shtml	1		NR
275	http://www.bom.gov.au/weather/wa/cyclone/about/faq/index.shtml#definitions	1		NR
276	http://www.britannica.com/eb/article-247917/tropical-cyclone	3		NR
277	http://www.britannica.com/eb/article-247919/tropical-cyclone	2		NR
278	http://www.britannica.com/eb/article-247925/tropical-cyclone	1		NR
279	http://www.britannica.com/eb/article-247928/tropical-cyclone	1		NR
280	http://www.britannica.com/eb/article-247931/tropical-cyclone	2		NR
281	http://www.britannica.com/eb/article-247941/tropical-cyclone	1		NR
282	http://www.britannica.com/eb/article-67116/ocean	2		NR
283	http://www.britannica.com/eb/article-67120	1		NR
284	http://www.britannica.com/eb/article-67121/ocean	1		NR
285	http://www.britannica.com/eb/article-9026084/convection	1		NR
286	http://www.britannica.com/eb/article-9026305/Coriolis-force	2		NR
287	http://www.britannica.com/eb/article-9042625/intertropical-convergence-zone	2		NR

288	http://www.britannica.com/eb/article-9072068/thermal-energy	1		NR
289	http://www.britannica.com/eb/topic-534748/sensible-heat	2		NR
290	http://www.britannica.com/search?query=tropical+cyclones&ct=	1		NR
291	http://www.brocku.ca/library/research.htm	5	*Brock database*	NR
292	http://www.chinadaily.com.cn/china/2007-11/05/content_6232141.htm	1		NR
293	http://www.classzone.com/books/earth_science/terc/content/visualizations/es1904/es1904page0cfm?chapter_no=visualization	1	*video*	NR
294	http://www.coaps.fsu.edu/~maue/tropical/	1		NR
295	http://www.columbia.edu/~ahs129/Papers/camargo_sobel_tellus.pdf+%22tropical+storm+formation%22&hl=en&ct=clnk&cd=2&gl=ca	1		NR
296	http://www.cs.ruu.nl/wais/html/na-dir/meteorology/storms-faq/part2.html	1		NR
297	http://www.ec.gc.ca/default.asp?lang=En&n=ECD35C36	1		NR
298	http://www.ed.gov/free/past/2005/92.html	1		NR
299	http://www.enn.com/ecosystems/article/28267	1		NR
300	http://www.experiencefestival.com/tropical_cyclone_-_formation	1		NR
301	http://www.faqs.org/qa/fqa2419.html	1		NR
302	http://www.faqs.org/qa/qa-6146.html	2		NR
303	http://www.faqs.org/qa/unrelated.html	1		NR
304	http://www.goldiproductions.com/images/cba/weather/insidehurricane.jpg	1	*image*	NR
305	http://www.hidaya.org/social-welfare/disaster-relief/bangladesh-cyclone-2007.html	1		NR
306	http://www.hko.gov.hk/informtc/informtc.htm	2		NR
307	http://www.howstuffworks.com/	1	*homepage*	NR
308	http://www.howstuffworks.com/framed.htm?parent=hurricane.htm&url=http://kids.earth.nasa.gov/archive/hurricane/tour.html	1	*video*	NR
309	http://www.irbs.com/bowditch/pdf/chapt36.pdf	1		NR
310	http://www.magma.ca/~harmony/MET/index.html	1		NR
311	http://www.magma.ca/~harmony/MET/page3.html	1		NR
312	http://www.magma.ca/~harmony/MET/page5.html	1		NR
313	http://www.metoffice.gov.uk/education/secondary/students/tropical_cyclones/Cyclone_Distribution.gif	1		NR
314	http://www.metoffice.gov.uk/weather/tropicalcyclone/	1		NR
315	http://www.metoffice.gov.uk/weather/tropicalcyclone/observations.html	1		NR
316	http://www.metoffice.gov.uk/weather/tropicalcyclone/tctracks/swi07_8.gif	1	*image*	NR
317	http://www.msc-smc.ec.gc.ca/acsd/crb/index_e.html	1		NR
318	http://www.msc-smc.ec.gc.ca/your_environment_e.html	1		NR
319	http://www.newhouse.co.nz/subjects/images/Z440.4.pdf	1	*pdf*	NR
320	http://www.nhc.noaa.gov/	2		NR
321	http://www.nhc.noaa.gov/2000.html	1		NR
322	http://www.nhc.noaa.gov/2000alberto.html	1		NR
323	http://www.nhc.noaa.gov/aboutnames.shtml	1		NR
324	http://www.nhc.noaa.gov/aboutrsmc.shtml	1		NR
325	http://www.nhc.noaa.gov/aboutrsmc.shtml?text	1		NR

326	http://www.nhc.noaa.gov/HAW2/english/basics/climo.shtml	3		NR
327	http://www.nhc.noaa.gov/HAW2/english/history.shtml	1		NR
328	http://www.nhc.noaa.gov/pastall.shtml	1		NR
329	http://www.nidm.net/Cyclones2.asp	1		NR
330	http://www.nintendo.ca/cgi-bin/usersite/display_info.cgi?pageNum=5&lang=en&id=3047403&from=ds	1		NR
331	http://www.noaanews.noaa.gov/stories2007/s2864.htm	1		NR
332	http://www.nrlmry.navy.mil/~chu/	1		NR
333	http://www.nrlmry.navy.mil/~chu/chap3/se000.htm	1		NR
334	http://www.nrlmry.navy.mil/~chu/chap3/se40htm	1		NR
335	http://www.nrlmry.navy.mil/tc_pages/tc_home.html	2		NR
336	http://www.ns.ec.gc.ca/weather/hurricane/hurricanes1bpic4.html	1	*image*	NR
337	http://www.ns.ec.gc.ca/weather/hurricane/hurricanes1bpic5.html	1	*image*	NR
338	http://www.ns.ec.gc.ca/weather/hurricane/hurricanes1epic2.html	1	*image*	NR
339	http://www.ns.ec.gc.ca/weather/hurricane/hurricanes1epic3.html	1	*image*	NR
340	http://www.ns.ec.gc.ca/weather/hurricane/hurricanes4.html	1		NR
341	http://www.ns.ec.gc.ca/weather/hurricane/hurricanes7.html	1		NR
342	http://www.ns.ec.gc.ca/weather/hurricane/hurricanes7a.html	1		NR
343	http://www.ns.ec.gc.ca/weather/hurricane/hurricanes7c.html	1		NR
344	http://www.ns.ec.gc.ca/weather/hurricane/hurricanes9b.html	1	*image*	NR
345	http://www.ntlib.nt.gov.au/tracy/advanced/Met/cyclones.html	9		NR
346	http://www.ntlib.nt.gov.au/tracy/advanced/Met/location.html	9		NR
347	http://www.ntlib.nt.gov.au/tracy/advanced/Met/Structure.html	4		NR
348	http://www.ntlib.nt.gov.au/tracy/advanced/Met/Threat.html	3		NR
349	http://www.ntlib.nt.gov.au/tracy/advanced/Met/Warning.html	2		NR
350	http://www.nws.noaa.gov/om/brochures.shtml	1		NR
351	http://www.pbs.org/wgbh/nova/teachers/viewing/3204_02_nsn.html	1		NR
352	http://www.prh.noaa.gov/	1		NR
353	http://www.prh.noaa.gov/cphc/pages/FAQ/Climatology.php	1		NR
354	http://www.prh.noaa.gov/hnl/cphc/	1		NR
355	http://www.rambocam.com/archive/whenwhere.html	1		NR
356	http://www.sciencemag.org/cgi/content/full/309/5742/1844	2		NR
357	http://www.solar.ifa.hawaii.edu/Tropical/	4		NR
358	http://www.solar.ifa.hawaii.edu/Tropical/tropical.html	5		NR
359	http://www.solar.ifa.hawaii.edu/Tropical/tropical_links.html	1		NR
360	http://www.springerlink.com/content/91n78548713u7075/	1		NR
361	http://www.springerlink.com/content/l50t664303201260/	1		NR
362	http://www.srh.noaa.gov/jetstream/tropics/images/hurr_cross.jpg	2	*image*	NR
363	http://www.srh.noaa.gov/jetstream/tropics/tc_basins.htm	6		NR
364	http://www.srh.noaa.gov/jetstream/tropics/tc_classification.htm	2		NR
365	http://www.thenweathernetwork.com/index.aspx?sid=4b3cc079-9012-45ee-b969-fc18c5c2d9b5&aid=6&pos=1&Keywords=Weather+Network&qs=06oENya4ZGJbLUrfP_LAbdglPPKFJcsqvxrwh--J9YPkbO6Ea3MVAlChMbb-vjO5L5wEdhpaFxzI2N-j01vSqik1QgH_mmtkWkCOocea-mvi0ia4sJ8Qr71	1		NR
366	http://www.theweathernetwork.com/	5		NR

367	http://www.theweathernetwork.com/index.php?product=glossary&pagecontent=glossaryindex&pagecontent=cyclone	2		NR
368	http://www.tropicalcyclone.net/	1		NR
369	http://www.ultimatechase.com/Hurricane_Video.htm	1		NR
370	http://www.ultimatechase.com/Video_Library/Hurricanes/Hurricane_Sat_Radar_Loops_Stream.htm	1	*video*	NR
371	http://www.usatoday.com/weather/hurricane/glossary.htm	1		NR
372	http://www.usatoday.com/weather/hurricane/glossary.htm?loc=interstitialskip	1		NR
373	http://www.usatoday.com/weather/hurricane/tropical-cyclone-basins.htm	10		NR
374	http://www.usatoday.com/weather/hurricane/whhistry.htm	1		NR
375	http://www.usatoday.com/weather/hurricane/whur7.htm	1	*latest news*	NR
376	http://www.usatoday.com/weather/tg/whurwhat/whurwhat.htm	2		NR
377	http://www.usatoday.com/weather/wstorm0.htm	1		NR
378	http://www.weather.com/ready/tropical/stages.html	1		NR
379	http://www.weather.gov.hk/informtc/informtc.htm	3		NR
380	http://www.weather.gov.hk/informtc/tcInfo.htm	1		NR
381	http://www.weather.nps.navy.mil/~cpchang/TWM-III/R10-B3e-Tropical%20Cyclones.pdf	1		NR
382	http://www.weathernetwork.com	1		NR
383	http://www.weathernetworkcanada.com/	1		NR
384	http://www.weatherwizkids.com/hurricane1.htm	1		NR
385	http://www.wikipedia.org/	2		NR
386	http://www.wiley.com/college/strahler/0471480533/animations/ch07_animations/animationhtml	1	*video*	NR
387	http://www.windows.ucar.edu/glossary/glossary_tropical_storm_formation.html	1		NR
388	http://www.windows.ucar.edu/tour/link=/earth/Atmosphere/hurricane/intensity.html&edu=mid&back=/search/search_navigation.html	1		NR
389	http://www.wmo.ch/pages/publications/meteoworld/archive/en/october2005/images/cyclonegraham02.jpg	1	*image*	NR
390	http://www.wmo.ch/web/www/TCP/rsmcs.html	1	*original - not found*	NR
391	http://www.worldalmanacforkids.com/WAKI-ViewArticle.aspx?pin=x-hu111400a&article_id=590&chapter_id=12&chapter_title=Science&article_title=Hurricane	1		NR
392	http://www.youtube.com/watch?v=IYNgD5qguLY	1	*video*	NR
393	http://www2.scholastic.com/browse/article.jsp?id=5178&FullBreadCrumb=%3Ca+href%3D%22%2Fbrowse%2Fsearch.jsp%3Fquery%3Dtropical+cyclone%26c1%3DCONTENT30%26c17%3D7%26c2%3Dfalse%22%3EAll+Results+%3C%2Fa%3E	1		NR
394	http://www2.scholastic.com/browse/search.jsp?query=tropical+cyclone&c17=7	1		NR
395	http://wwwinterscience.wiley.com:8100/legacy/college/strahler/0471238007/animations/ch07_animations/animationhtml	1		NR

396	https://www.meted.ucar.edu/loginForm.php?urlPath=hurrican	1	NR
397	SPORTS SITES	1	NR

NR = non-relevant webpage; R = website contains at least some information that is relevant for the assigned topic

Appendix J: List of Unique Search Terms

Category	Subcategory	Terms	Percentage of Participants
specific			
	cyclone formation		
		cyclone formation	2.35%
		formation of cyclones	2.35%
		how cyclones form	2.35%
		storm cyclones formation	1.18%
	tropical cyclone formation		
		formation of a tropical cyclone	2.35%
		formation of cyclones tropical	1.18%
		formation of tropical cyclone	22.35%
		how are tropical cyclone formed	2.35%
		how do tropical cyclone form	12.94%
		how tropical cyclone are formed	3.53%
		how tropical cyclone form	29.41%
		tropical cyclone & how they are formed	1.18%
		tropical cyclone + formation	1.18%
		tropical cyclone and its formation	1.18%
		tropical cyclone are formed?	1.18%
		tropical cyclone form	10.59%
		tropical cyclone formation(s)	27.06%
		tropical cyclone formation video	1.18%
		tropical cyclone formed	2.35%
		tropical cyclone, how do they form	1.18%
		the forming of tropical cyclone	1.18%
		why do tropical cyclone form	1.18%
		step-by-step formation of tropical cyclone	1.18%
	tropical storm formation		
		tropical storm formation	5.88%

		how do tropical storms form	1.18%
	other variation of formation		
		cause of tropical cyclone	2.35%
		how cyclones occur	1.18%
		how do cyclones develop?	1.18%
		how do cyclones start	1.18%
		how do tropical storms occur	1.18%
		how do tropical storms start	1.18%
		tropical cyclone creation	1.18%
		what causes tropical cyclone	1.18%
		why cyclones occur	1.18%
	hurricane formation		
		formation of a hurricane	2.35%
		hurricane formation	2.35%
general			
		cyclone	1.18%
		tropical cyclone	45.88%
		tropical cyclone how	1.18%
		tropical storms	4.71%
		Hurricanes	2.35%
		tropical cyclone for kids	1.18%
other			
		"convergence" definition	1.18%
		"convergence" definition meteorology	1.18%
		"surface convergence"	1.18%
		"surface convergence" definition meteorology	1.18%
		surface convergence definition	1.18%
		coriolis effect (some spelling)	3.53%
		coriolis effect animation	1.18%
		deaths caused by tropical cyclone…	1.18%
		define AMEDC	1.18%
		define MEDC	1.18%
		define: coriolis force	1.18%
		definition of coriolis effect	1.18%
		effects of cyclones of the ocean	1.18%

	famous cyclones & how they form	1.18%
	hurricane andrew	1.18%
	history of tropical cyclone	1.18%
	latent heat of condensation	1.18%
	list of major tropical cyclone in past decade	1.18%
	location formation of cyclone	1.18%
	MEDC	1.18%
	meteorology	1.18%
	parts of a tropical cyclone	1.18%
	recent tropical cyclone	1.18%
	what is a tropical cyclone	1.18%
	tropical cyclone in history	1.18%
	tropical cyclone worldwide	1.18%
	tropical storm structure	1.18%
	tropical storm systems	1.18%
	tropical cyclone & their effects	1.18%
	types of tropical storm	1.18%
websites		
	britannica encyclopedia	1.18%
	brock	2.35%
	canadian hurricane center	1.18%
	cyclone formation youtube	1.18%
	gc.ca	1.18%
	Google	1.18%
	yahoo search	1.18%
	national hurricane center + tropical cyclone	1.18%
	national weather center	1.18%
	national weather center + tropical cyclone	1.18%
	weather Canada	1.18%
	weather network	4.71%
	tropical cyclone wiki	1.18%
	formation tropical storm wiki	1.18%
	wikipedia	1.18%
	wikipedia tropical cyclone	2.35%
	cyclones wiki	1.18%

Appendix K

Comparison of variables as a function of gender for participants in the Internet condition

	Male		Female			
Variable	*M*	*SE*	*M*	*SE*	*t* statistic	*p*
Achievement	42.86	2.47	40.99	1.47	0.63	0.53
Invested mental effort	2.50	0.31	2.17	0.18	0.90	0.37
Time spent with relevant info	0.38	0.04	0.46	0.02	1.89	0.06
Essential pages	0.50	0.06	0.59	0.03	1.51	0.13
Windows[1]	0.42	0.04	0.36	0.02	1.77	0.08
Search engines	0.31	0.02	0.36	0.12	1.73	0.09
General terms	0.50	0.11	0.57	0.07	-0.47	0.64
Specific terms	0.85	0.11	1.08	0.06	-1.76	0.08
Reading comprehension	35.50	2.20	36.31	1.09	0.35	0.73
Raven's	50.85	0.96	49.46	0.62	1.12	0.26
Internet knowledge	2.55	0.17	2.48	0.09	0.40	0.69
Topic knowledge	2.30	0.28	1.98	0.14	1.05	0.30
Motivation	7.55	0.23	6.91	0.19	1.72	0.09
WM control	6.35	0.73	5.54	0.56	0.75	0.46
Distractibility	1.46	0.08	1.47	0.04	-0.14	0.89
Intrinsic	4.97	0.27	4.51	0.13	1.66	0.10
Effort regulation	4.91	0.25	4.80	0.16	0.36	0.72
GEFT	12.7	1.01	12.33	0.52	0.34	0.73

Note. Sample consisted of 20 males and 65 females. All reported t-values were obtained using $df = 83$. WM = working memory.
[1]. Variables included in analysis underwent a log10 transformation.

Appendix L

Comparison of variables as a function of gender for participants in the control condition

	Male		Female			
Variable	*M*	*SE*	*M*	*SE*	*t* statistic	*p*
Achievement	25.71	4.97	17.63	3.99	1.05	0.31
Internet knowledge	3.00	0.32	2.38	0.12	2.22	0.12
Topic knowledge	3.80	1.15	1.75	0.21	1.74	0.15
Motivation	4.80	0.37	5.03	0.39	0.32	0.76

Note. Sample consisted of 5 males and 16 females.

Appendix M: Zero Order Correlations Among All Variables

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
1. age																			
2. achievement	-0.12																		
3. reading comp	0.05	*0.25*																	
4. general mental ability	0.16	0.15	**0.28**																
5. Internet knowledge	0.15	0.01	0.14	0.19															
6. topic knowledge	-0.11	0.20	-0.02	0.04	0.02														
7. overall motivation	0.11	0.21	-0.08	-0.02	0.15	0.10													
8. time with rel. info	-0.03	**0.33**	-0.04	0.08	-0.06	-0.15	-0.09												
9. prop. of revisiting	0.09	*0.22*	0.01	0.13	0.09	-0.18	0.00	**0.38**											
10. prop. of rel. pages	-0.01	0.13	-0.19	-0.13	-0.10	-0.16	-0.06	**0.64**	0.20										
11. total rel. pages	-0.16	0.11	0.21	0.03	0.09	-0.10	-0.02	**0.29**	-0.04	**0.28**									
12. total irrel. pages	-0.04	-0.09	*0.27*	0.02	0.02	0.09	0.06	**-0.47**	-0.20	**-0.80**	0.07								
13. prop. rel. page > 60s	0.11	0.13	-0.07	-0.03	-0.02	*-0.25*	-0.09	**0.55**	*0.23*	**0.53**	**0.32**	**-0.32**							
14. total rel. pages > 60s	-0.19	0.06	0.04	-0.03	-0.05	*-0.24*	-0.01	**0.35**	-0.05	**0.38**	**0.73**	-0.09	**0.43**						
15. total irrel. pages > 60s	-0.10	-0.10	0.12	0.01	-0.01	0.18	0.12	**-0.55**	*-0.23*	**-0.51**	**-0.27**	**0.36**	**-0.95**	**-0.36**					
16. max # windows	-0.07	0.05	0.15	0.18	*0.24*	0.00	-0.03	-0.01	**0.44**	-0.15	0.06	0.16	-0.07	0.02	0.06				
17. # search engines	-0.16	-0.05	0.01	**-0.28**	0.19	-0.04	0.04	-0.08	0.08	-0.17	0.10	0.18	-0.12	0.06	0.13	0.02			
18. # specific terms	-0.02	0.13	*0.25*	0.03	0.07	*-0.22*	0.05	0.20	0.06	0.07	**0.36**	0.12	0.20	**0.35**	-0.16	0.17	*0.25*		
19. # general terms	-0.08	-0.15	0.14	0.09	-0.07	0.04	-0.10	-0.19	-0.15	**-0.44**	0.01	**0.56**	-0.22	-0.05	*0.25*	0.18	0.16	0.00	
20. WM control	-0.02	-0.07	0.14	0.20	0.10	0.18	-0.15	0.04	0.07	-0.02	-0.02	-0.08	-0.04	0.01	0.02	-0.03	0.06	-0.05	-0.05
21. distractibility	**-0.29**	-0.11	-0.07	0.10	-0.11	-0.13	**-0.29**	0.14	0.01	0.03	0.10	0.05	0.09	0.10	-0.12	0.00	-0.01	0.08	0.06
22. GEFT (n = 84)	0.11	0.10	*0.24*	**0.47**	*0.24*	*-0.26*	0.14	-0.13	0.09	-0.20	0.13	0.14	-0.11	-0.12	0.12	0.36	0.03	0.16	0.11

(continued)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
23. intrinsic goal orientation	*0.23*	0.05	0.07	*0.24*	*0.22*	**0.32**	**0.27**	**-0.29**	-0.16	**-0.32**	*-0.23*	0.14	-0.21	**-0.25**	0.20	0.05	-0.07	-0.11	-0.05
24. effort regulation	**0.34**	-0.04	-0.08	0.07	*-0.23*	0.13	**0.28**	-0.15	-0.11	0.01	-0.20	-0.07	-0.03	-0.13	0.03	-0.21	**-0.26**	-0.13	0.00
25. ACPS	-0.14	**0.31**	-0.03	0.12	-0.07	0.11	0.10	-0.05	0.06	0.11	-0.03	-0.09	-0.04	-0.03	0.11	0.06	-0.04	-0.03	-0.07
26. increases in mental effort	-0.15	*0.25*	0.09	0.00	0.16	-0.06	0.10	*0.24*	0.29	0.10	0.18	0.02	0.21	*0.22*	-0.20	**0.31**	0.10	**0.27**	-0.10
27. Subjective mental effort	0.07	-0.08	-0.09	0.06	-0.12	0.08	0.12	-0.14	0.06	-0.13	*-0.25*	0.01	*-0.24*	-0.18	*0.22*	0.05	-0.09	-0.18	-0.11
28. Subjective difficulty	0.12	-0.19	-0.08	-0.01	-0.13	0.01	0.03	0.01	-0.12	-0.07	0.12	0.17	0.11	0.16	-0.11	-0.07	-0.07	-0.07	0.01
29. difficulty to find rel. info (n= 82)	-0.20	-0.20	-0.06	-0.12	*-0.24*	0.10	-0.10	-0.08	-0.04	-0.12	-0.01	0.14	0.01	-0.04	-0.05	0.12	0.00	0.05	0.11

	20	21	22	23	24	25	26	27	28
20. WM control									
21. distractibility	-0.06								
22. GEFT (n = 84)	-0.08	0.10							
23. intrinsic goal orientation	0.12	**-0.35**	-0.03						
24. effort regulation	0.02	**-0.30**	-0.12	**0.45**					
25. ACPS	-0.02	0.06	0.08	0.00	0.06				
26. increases in mental effort	-0.13	0.16	0.06	-0.19	**-0.30**	0.08			
27. Subjective mental effort	-0.01	0.17	0.11	0.07	-0.05	-0.14	-0.04		
28. Subjective difficulty	*-0.22*	*0.25*	0.03	-0.05	0.00	-0.15	0.04	**0.41**	
29. difficulty to find rel. info (n= 82)	0.08	0.15	-0.05	-0.14	-0.05	-0.16	0.05	0.17	*0.24*

Note. WM = working memory; ACPS = average change in pupil size (SDs); *p*'s < 0.01 are in bold and *p*'s < 0.05 are in italics

Appendix N: Illustration of the Eye-tracker Setup